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The role of suppliers in the market of reused construction materials

A supply chain perspective

Master's thesis in Supply Chain Management

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SUMMARY
The construction industry is the industry that is using the largest amount of natural resources. The model of the construction industry has for decades been to “take, make, use, dispose”, a linear model not allowing materials in properties to be reused. Changing the construction industry to a circular model including reuse of construction materials is a way to reduce the impact on the climate from the construction industry.

The suppliers of construction materials possess an important role in the transformation of scaling up the market of reused materials. Thus, the purpose of this thesis is to identify and analyze the Supply Chain role of suppliers in the market of reused construction materials. The research is based on interviews with 29 actors in the construction industry. First, actors involved in three projects were identified and interviewed, to create a holistic view of how the market of reused materials function. Thereafter, other actors, for instance suppliers, were interviewed to create an understanding of how different stakeholders in the construction industry work with reused materials.

The interviews resulted in information about three projects and the processes of working with reused materials from a supplier’s and reuse hub’s point of view. Furthermore, it contributed with information about market drivers for the reuse market, challenges, collaboration and opinions about the future of the reuse market.

Seven actors were identified as included in the market of reused materials. These are property owner, construction company, reuse consultant, supplier, reuse hub, architecture firm and demolition firm. Furthermore, several resources controlled by the actors and activities performed by them were identified.

A number of key factors influencing the reuse market is discussed in the thesis. These factors are environmental sustainability, costs, market requirements, collaboration, communication, procurement process, logistics, matching supply and demand, and supplier capacity.

The result from the study implies that suppliers possess an important role in the transformation of the reuse market. There are four main activities suppliers should implement to establish work with reused materials. First, they need to adapt operations to enable circular flow. Secondly, they need to focus on the take back process. Furthermore, the process at the suppliers must be updated, and finally the selling process of reused materials needs to be implemented.

Keywords: Circularity, reverse logistics, reuse of materials, circular business models, collaboration, construction industry, supply chain management, industrial networks, ARA model

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1. Introduction

Among all industries, the construction industry is the one using the largest number of natural resources (Ghufran et al., 2022). The model of construction industry has for decades been to "take, make, use, dispose", a linear model not allowing materials in buildings to be reused. According to Castell-Rüdenhausen et al. (2021), it is still the model used to the greatest extent today. In 2020, the construction industry represented 40% of all disposals in Sweden (Boverket, 2024). This implies 14.2 million tons of materials ending up as disposals instead of being reused in the industry. According to Boverket (2024), a circular model including reuse of construction materials is a way to reduce the impact of the climate from construction industry.

The European Union has several regulations to foster reuse of materials and circular economy in the construction industry (CFP Green Buildings, 2024). The European Green Deal is one of them, aiming a climate-neutral Europe by 2050. Connected to this strategy, other regulations are created covering the construction industry. The circular economy action plan (CEAP) is an initiative, implying actions to reduce pressure on natural resources, adapted on all parts of the life cycle of products (European commission, n.d). Thus, CEAP includes and enhances the reuse of construction materials. Sweden has conducted their own environmental goals, in line with the regulations of the European Union (Boverket, 2024). One environmental goal of Sweden is that 70% of all construction- and demolition disposals should be recycled or reused by 2025.

According to Ghufran et al. (2022), there has been little research on the circular economy concept in the construction industry. Accordingly, Boverket (2024) states the interest in reuse of construction products is increasing, but the scope is still very limited. Furthermore, there is a lack of competence within the area. Construction logistics is a major part of the construction industry, including different phases of managing materials connected to the construction site (Ding et al., 2023). Forward logistics is a commonly used term within construction logistics, explaining the processes from design to delivery. Another term not equally commonly used is reverse logistics, from deconstruction to reuse or recycling. According to Ding et al. (2023), it is important to combine forward and reverse logistics to succeed with circularity in construction industry. Currently there is a lack of developed processes regarding reused construction materials, resulting in no comprehensive and united structure of what is being reused and not (Boverket, 2024). This in combination with regulations from the European Union and Sweden emphasizes the need for further investigations within reused materials in the construction industry.

A research project was conducted in collaboration between AFRY, Chalmers University of Technology and Linköping University, mapping the role of construction logistics as an enabler for circular materials flows in the construction industry (Bosch et al., 2023). Several actors were

identified as important, where material suppliers are one. One conclusion from the research project is the possibility for material suppliers to include reused materials in their business. Thus, AFRY initiated this thesis with the focus on evaluating supplier's supply chain role in the market of reused construction materials.

AFRY is a consultancy firm, with an extensive portfolio including for instance engineering buildings and circular systems. Their mission is to *"accelerate the transition towards a sustainable society"*. Since AFRY is a consultancy firm, they work closely with a variety of actors to create viable and sustainable solutions for the construction industry, where reuse of construction materials is an area of increasing interest. This promotes a comprehensive analysis of the construction industry, and the role of suppliers in offering reused construction materials. This leads us to the purpose of the master thesis.

1.1 Purpose

The purpose of this master thesis is to identify and analyze the supply chain role of suppliers in the market of reused construction materials.

1.2 Research questions

The purpose of the master thesis leads to the following research questions:

- RQ1: What current actors, resources and activities are identified in the market of reused construction materials?
- RQ2: What key factors affect the supply chain role of suppliers in the market of reused construction materials?
- RQ3: What activities should suppliers be responsible for in their supply chain role regarding the development of the reused construction materials market?

1.3 Scope

The master thesis evaluates the role of construction material suppliers in the construction industry. The term supplier is explained as the actor manufacturing the construction material. Whoever the supplier is from the customer's point of view, this master thesis focuses on the actor manufacturing the construction material. However, the report has found that one wholesaler has the competence to perform reconditioning. As an exception, that wholesaler who possess reconditioning skillset is also included in the term suppliers.

This master thesis focuses on the supply chain of reused materials in the construction industry in Sweden. Since the operations of AFRY are well developed in Sweden, this is where the scope

is limited to. This creates opportunities for comprehensive analysis of the supply chain of reused materials in the construction industry in Sweden, enabling detailed information about relevant subjects. However, there are regulations from the European Union affecting the construction industry in Sweden. Other countries in the Nordics and Europe also follow these regulations, leading to more countries than Sweden could benefit from this master thesis. The suppliers of the construction materials potentially work with other actors outside of Sweden, implying the results are applicable in the business models of the suppliers in other countries than Sweden.

2. Methodology

To achieve the purpose of the master thesis, to analyze and evaluate the supply chain role of suppliers in the market of reused construction materials, relevant methods were chosen. The first part of the chapter explains the data collection, where qualitative interviews and data collection from webpages were the methods used. The next part of the chapter provides information about literature review, where relevant databases and keywords are expressed. The third part of the chapter implies analysis of the empirical data. Finally, the methods are discussed in terms of validation and reliability.

2.1 Data collection

The subject of this report is an area that is relatively unexplored which complicates the gathering of data. Therefore, qualitative interviews were a viable option to create an understanding of the current situation because of the method's flexible nature (Bell et al., 2022). Semi-structured interviews were used, and the process is explained in this chapter. Furthermore, documentary data was utilized to complement the empirical data from interviews.

2.1.1 Qualitative interviews

The process of interviews began with a list from AFRY of potential stakeholders in the construction industry potentially valuable for the data collection. From that list, five representatives where chosen, from different stakeholders in the construction industry to get a first insight into the market of reused materials. The stakeholders differed from each other to be able to gather as comprehensive first insight as possible. The representatives where one supplier, one researcher, one construction company, one consultancy firm within reused materials and one software supplier.

For the main data collection, the representatives contacted were found through searching online and from the list provided by AFRY. First, three projects focusing on reused materials were identified. Stakeholders connected to the specific projects were chosen as representatives to create a holistic view of how the market of reused materials function. Furthermore, representatives from the different stakeholders within the construction industry focusing on reused materials were interviewed. This with the purpose of creating an understanding of how different stakeholders in the construction industry work with reused materials. A total of 29 representatives were interviewed, and they are presented in Table 2.1.

All questions were sent one day in advanced to each representative to create possibilities for the person to prepare in order to get as much value of the interview as possible. Semi-structured interviews will covered specific topics of the researchers choosing (Bell et al., 2022). The interview questions contained topics such as material flow, success factors, challenges,

collaboration and the supplier's role in the industry. Although specific topics was covered in the interview, follow-up questions on the representative's statements appeared on spontaneous nature. Some questions were adapted to the specific actor, and some questions were asked to all representatives.

All interviews except four were performed through teams. Both researchers were a part of the interview, where one had the responsibility to ask the questions, and the other one compiled notes. However, the person taking notes could also ask questions. Qualitative interviews are flexible where the researcher may follow up on the representative's answers and may abandon the interview guide at occasions (Bell et al., 2022). However, it is of importance to keep the interviews flexible to give the representative the opportunity to answer the questions to their maximum capacity. Since the interviews were semi-structured, there was room for both the researchers and representative to deviate from the structure of the interview. However, the researchers ensured all questions were answered. Considering that the supply chain of reused construction materials is unexplored, the use of semi-structured interviews may create a foundation of understanding as well as gather opinions as well as thoughts relevant to the research questions.

Table 2.1. *Description of representative ID, company, connected project, role, type and date of the conducted interviews.*

R-ID	Company	Project	Company description	Role of representative	Type	Date
1	Architecture firm A	Z	Swedish architecture firm specializing in sustainable design and urban planning	Sustainability coordinator	Teams	2025-03-13
2	Construction company A		Municipal company specializing in real estate development	Project manager	Teams	2025-02-12
3	Construction company B	X	Major construction company in Sweden	Project director	Office	2025-03-04
4	Construction company B		Major construction company in Sweden	Site Manager	Teams	2025-03-13

5	Construction company C	Y	Construction company present in Gothenburg, Sweden	Business manager	Teams	2025-03-05
6	Construction company D		Construction company with presence in West of Sweden	Project manager	Teams	2025-03-25
7	Consultant A		Reuse consultancy firm specializing in reuse and sustainable solutions	CEO & reuse consultant	Teams	2025-02-13
8	Consultant B		Swedish engineering consultancy specializing in construction services and sustainability	Strategic sustainable manager	Office	2025-03-13
9	Consultant C		Logistics consultants, currently managing flow of reused materials	Reuse coordinator	Teams	2025-03-18
10	Demolition firm A	Z	Demolition firm who also offers dismantling services	Site manager	Teams	2025-03-14
11	Property Owner A		Swedish property owner focusing on property management and development	Project director	Teams	2025-03-12
12	Property Owner A	Y & Z	Swedish property owner focusing on property management and development	Project director	Teams	2025-03-13

13	Property Owner B	Swedish property owner specializing in developing commercial properties	Project director	Teams	2025-03-12
14	Property Owner C	Property owner with presence in Stockholm, Sweden	Sustainability specialist	Teams	2025-03-12
15	Property owner D	Property owner with a great share in Sweden	Sustainability specialist	Teams	2025-03-18
16	Reuse Hub A	Reuse Hub with presence in projects and sells reused materials	Chief of site	Teams	2025-03-06
17	Software Supplier A	Supplier of a digital platform to enable reuse of materials	Seller and Chief of sell	Teams	2025-02-18
18	Reuse supplier A	Swedish supplier focusing on sustainable carpet recycling and reuse solutions	CEO	Teams	2025-03-06
19	Reuse supplier B	Leading Swedish supplier of reused bricks	CEO	Teams	2025-03-14
20	Supplier A	International floor supplier with heavy presence in Sweden	Key Account Manager and Sustainability representative	Office	2025-02-07, 2025-03-05
21	Supplier B	Leading Nordic, timber, wood, and construction company	CEO	Teams	2025-03-07

22	Supplier C	Supplier of glass and installation services	Part-owner	Teams	2025-03-13
23	Supplier D	Swedish manufacturer of indoor climate and ventilation solutions	Key Account Manager and Sustainability representative	Teams	2025-03-21
24	Supplier E	Swedish manufacturer specializing in acoustic ceiling and wall solutions	Circularity manager & Sustainability specialist	Teams	2025-03-27
25	Wholesaler A	Swedish wholesaler specializing in building materials and construction supplies	Project manager of reuse	Teams	2025-03-07
26	Wholesaler B	Swedish steel wholesaler and distributor, offering reused materials	Reuse business developer	Teams	2025-03-10
27	Wholesaler C	Swedish distributor of products & services for the construction, industrial and HVAC sectors	Sustainability chief	Teams	2025-03-18
28	Wholesaler C	Swedish distributor of products & services for the construction, industrial and HVAC sectors	Chief of logistics	Teams	2025-03-19
29	University A	Current employee at two Swedish universities	Researcher within construction logistics	Office	2025-02-11

2.1.2 Documentary data

Qualitative research includes collection of written data from several different sources (Bell et al., 2022). Websites of authorities, for instance Boverket, provided important information which benefited the research project. Other sources of information are sustainability reports of companies within the construction industry, and policy documents related to the supply chain of reused materials in the construction industry.

2.2 Literature review

Literature review was conducted to collect information about relevant subject areas (Bell et al., 2022). The literature review was used as a basis for the empirical data, to combine them later in the project. On one hand, it also provides already existing information about the research topics, to eliminate double work. On the other hand, the literature review assists in finding the gaps within the research topic.

According to Bell et al. (2022) there are different ways of approaching literature review. The different approaches explain to what extent the coverage of the subject area is today. Since the topic of reusing construction materials in the construction industry, more specific the role of suppliers within the field, is a relatively unexplored subject area, the "exhaustive coverage with selective citation" approach will be used in this research project. This implies a major amount of literature will be reviewed, and the most important parts will be applied in the research project.

To search for relevant theoretical frameworks, several sources were used. Databases such as Scopus and Google Scholar contributed to academic research within the relevant topics. The academic research provided concepts and frameworks already existing in the field of research.

Common keywords for the research project: *Circularity, reverse logistics, reuse of materials, circular business models, collaboration, construction industry, supply chain management*, *industrial networks, ARA model.*

2.3 Data analysis

Thematic analysis was conducted on the data collection. The aim of thematic analysis is to interpret and identify key features of the data collection, supported by the research questions (Clarke & Braun, 2017). According to Braun and Clarke (2006), the thematic analysis is a step-by-step guide, consisting of six steps. The first step is to transcribe the data. Step number two implies to generate initial codes. All interviews were recorded and transcribed. After each interview, the notes taken were combined with the content from the transcription and the recording. Important quotations were documented to use in the report and unnecessary words

were removed from the transcription. Step number three is to search for themes. This is a broader analysis of the data collection, where the summaries are gathered into different themes (Braun & Clarke, 2006). From the interview questions, key words were chosen to structure the summaries of the interviews. In the summary of all interviews, the key words were used as searching words, to find the data connected to the specific key word. For instance, one key word was “process”. In the document, the word “process” was identified to find the different processes of reused materials. Those key words became the themes and were then developed to different sub-themes. After finding themes, the fourth step is to review the themes (Braun & Clarke, 2006). This implied going through the themes to find the most appropriate ones for the report, and also to see if some themes could be gathered into one. The fifth step implies define and name the themes (Braun & Clarke, 2006). Some of the key words chosen from the interview questions, were changed and redefined to match the content within each theme. Finally, the last step is to produce the report (Braun & Clarke, 2006). In this step, the themes were used as titles for the empirical data chapter. The most important data from the summaries were written in the report, and quotations were written to get a more realistic view of the opinions of the representatives.

2.4 Validation and reliability

Since the market of reused materials is an explorative and relatively new area, there is not enough theory to validate and assure the reliability of the conducted interviews. However, all interviews were performed with representatives working with reused materials. The webpages of the companies provided information about people closest to their work with reused materials.

A majority of all representatives contacted were willing to be interviewed. Some of them which were not willing recommended another representative more relevant for the subject. The representatives were chosen with the purpose of getting a comprehensive view of the market of reused materials in the construction industry. However, within some actors, only one representative was interviewed. This was because it was the only actor found working with reused materials when searching the internet. This could give a narrow scope of the reused materials for that certain actor group which is important to consider. For project X, only one actor was interviewed. This was because the representative of the other main stakeholder was not still working at that company. However, the representative interviewed was project director and contributed with a lot of valuable information.

3. Theoretical Framework

The construction industry has for centuries been linear, where virgin raw materials are extracted, the material is refined, used and then disposed of (Benachio et al., 2020). The scope is limited to the use of material, and not how to take care of it in the end of life state. During the recent years, the focus has shifted more towards circularity and how to create opportunities for longer life cycles of the material used in construction projects. In order to move towards a circular construction industry, there are many new things to consider. The business models need to be adapted to the construction industry, collaboration among stakeholders becomes essential and circularity needs to be adapted to all parts of the supply chain, not only certain parts.

The chapter includes theoretical frameworks promoting circularity in the supply chain management of the construction industry. Furthermore, it explains how actors, activities and resources are connected using the industrial network approach. All the theories are considered a foundation for the analysis later in the report.

3.1 Circularity in supply chain management

The circular economy is essential for transforming construction logistics by promoting sustainable practices that reduce waste and optimize resource use (Van Weele & Rozemeijer, 2022). Traditional linear models, where materials are used once and discarded, lead to inefficiencies and environmental harm. The circular economy addresses this by emphasizing continuous reprocessing of materials, designing products for disassembly, and prioritizing recycling. Circular sourcing is key, encouraging the procurement of materials with high recycled content and those that can be easily reused or repurposed. This shift focuses on functionality rather than ownership, enabling businesses to reduce the need for raw materials through leasing or sharing products. In construction logistics, circular economy principles help recover and reuse materials like metals, plastics, and timber, minimizing waste and reducing costs. Adopting circular practices fosters sustainability in procurement and supply chains, helping companies transition from traditional models to a more efficient, resource-conscious, and resilient industry.

3.1.1 Scenarios in the reused construction materials market

AFRY did a research project together with Chalmers University of Technology and Linköpings University (Bosch et al., 2023). The project resulted in four scenarios explaining the different roles of construction logistics in the market of reused materials. The complexity increases from scenario one to four regarding planning, organization, coordination and control of material flow of reused materials. It also leads to more and new relationships between the actors. The four scenarios are presented in Figure 1.

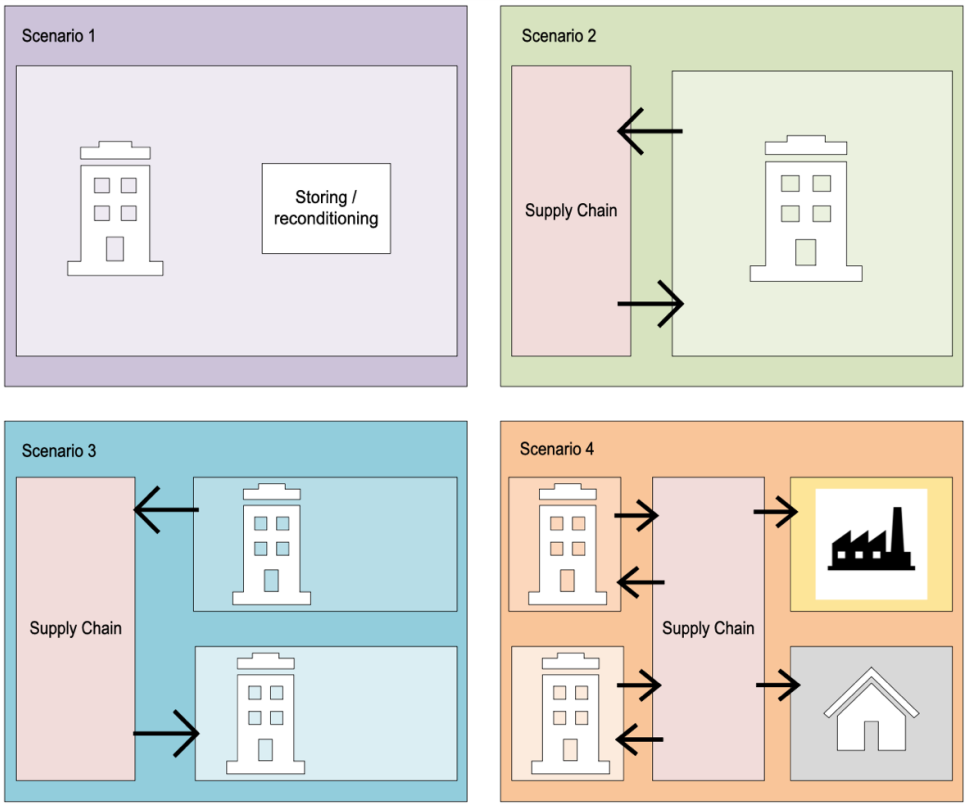

Figure 1: Modification of the four scenarios (Bosch et al., 2023)

The first scenario implies the material is reused within the same construction site (Bosch et al., 2023). The material is dismantled and stored at the construction site until needed. Potential reconditioning of the material occurs at the construction site. Necessities crucial for succeeding with scenario one is a dedicated storing area at the construction site, where traceability of the material is important.

In scenario number two, the material is reused within the same construction site, but it is stored outside of the construction site (Bosch et al., 2023). This implies other parts of the supply chain is involved. Recondition occurs either on the construction site or at another place in the supply chain. Compared to scenario one, scenario two contributes to freed-up storage space at the construction site, while the material is protectively stored. However, scenario two implies transporting the material from the storage to the construction site, leading to potential increased transportation costs and emissions.

The third scenario implies the material is reused within the same organization, but in another construction project (Bosch et al., 2023). The complexity increases in scenario three since it requires coordination among the different construction sites. It usually also results in more actors needed. Systemization is essential to know what material is available, and planning and storing of material is required if the material from one construction site is not needed directly.

Scenario four is the most complex scenario, where material from one construction project is reused in another construction project, industry or for private use (Bosch et al., 2023). Material from several construction projects is stored and managed by actors in the construction industry and then transported and used in other construction projects. Recondition occurs either on one of the construction sites or at another place.

In all scenarios traceability is a common enabler. It is important to be able to track the material. However, it becomes more complex and essential in scenario three and four because the increase in actors involved.

3.1.2 Collaboration tool

A shift towards more circular supply chain management is essential for the construction industry (Leising et al., 2017). When implementing circular concepts in supply chain management, it is of highest importance to involve not only certain actors, but all actors in the supply chain from suppliers to end users, and then demolishers and waste companies. Leising et al (2017) define circular economy in supply chain management as stated below.

"*Connecting a network of actors in their supply chain by managing data transparency, material flow and exchanges, responsibilities, predictability and sharing benefits*." (Leising et al., 2017; p.977).

Leising et al (2017) created a collaboration tool to facilitate the developing of circular supply chain management. The framework consists of five phases, from preparation and vision development to usage and prepare for next use.

The first phase implies the customer to create a vision for the material and the collective process instead of focusing on specific requirements for a construction project. According to Leising et al (2017) creation of this vision is essential for transforming to a circular industry, and appropriate to use in pilot projects. The customer needs to be a leader and start the work of a circular vision, and from that include other actors in the supply chain. A vision for the future should facilitate alignment among heterogeneous stakeholders and serve as a guiding framework for coordinated action.

Phase number two contains involvement of the market and supply chain (Leising et al., 2017). In this phase, the actors involved should be grounded in disciplines required for the construction project instead of particular companies. One concept within phase two is actor learning, and it exists first order learning and higher order learning. The higher order learning is important to execute when transforming the construction industry to circular, since it implies changes in values, definitions and goals of actors. According to Leising et al (2017) this phase contributes to new collaborations focusing on value added activities for the total life cycle of the construction project, instead of each actor focusing on its usual activities. Yang et al (2022)

also states the importance of involving several actors in the supply chain of the construction industry. Companies taking back the material is heavily dependent on customers returning the materials and closed-loop relationships therefore become essential.

The third phase is to design the process and collaboration (Leising et al., 20127). The collaboration is formalized by non-traditional contracts aiming on collaboration instead of comprehensive specifications and clearly allocated responsibilities.

Phase number four is about implementation and creation of business model (Leising et al., 2017). The construction part begins, and development of new business models is necessary. The business model needs to be based on collaborative financial incentives, instead of uncoordinated initiatives where each actor aims towards the highest margin possible for its own activities. They must aim towards collaborative value in the network of actors, instead of focusing on a certain company. Furthermore, it is important to change the business model to not only focus on economic benefits, but also to contribute with environmental and social value to the construction project. One example of change in the business model could be the ownership of materials when focusing on reused materials.

The last phase is usage and prepare for next use (Leising et al., 2017). This implies assurance of maintaining the material value by for instance reusing it. Supplier involvement is essential in this phase to either create a model where they take back the material ones used, either through leasing to property owners or buying it back. This phase creates opportunities to use the material and collaboration in the first phase when starting a new construction project.

The model is presented in Figure 2.

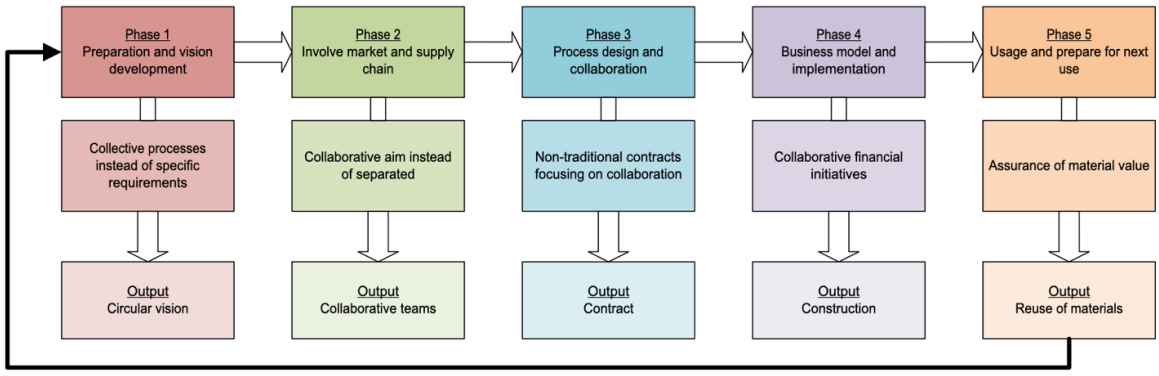

Figure 2: Modification of the collaboration tool model (Leising et al., 2017).

Leising et al (2017) analyzed two companies implementing circular concepts, focusing on reused materials and identified six sustainable business model innovations each. One common success among the two companies was the use of resource passports to monitor the material through the life cycle of the construction project. A resource passport contains information

about the composition, quality and origin of the material (Markou et al., 2025). The resource passport facilitated the take back management of materials for both analyzed companies (Leising et al., 2017).

3.1.3 Design for circularity framework

Dewagoda et al (2022) created a framework to facilitate the design of circularity in the construction industry. It consists of four core and four support elements. Figure 3 presents the design for circularity framework.

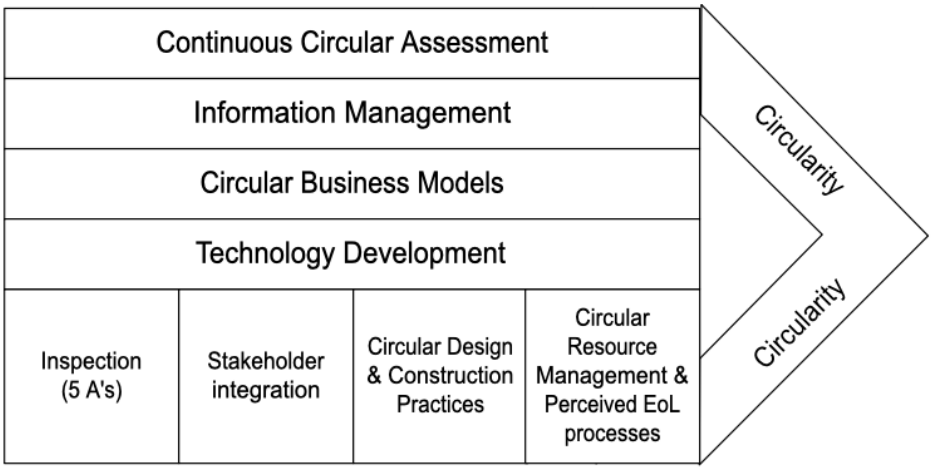

Figure 3: Modification of the design for circularity Framework (Dewagoda et al., 2022)

The core elements are inspection, stakeholder integration, circular design and construction practices, and circular resource management and perceived End of Life processes (Dewagoda et al., 2022). Inception implies 5A's, namely five concepts important as a foundation towards circularity. **Awareness** explains the necessity of stakeholders, especially customers, must be aware of what circularity means and its benefits. Furthermore, the stakeholders need a positive **attitude** toward using reused materials. The stakeholders also need **acceptance** to adopt circular economy practices, for instance reused materials. **Agreement** among the stakeholders is important to create common understanding and alignment on circularity goals. Lastly, **apprehension** is essential, implying having the knowledge and expertise to properly implement reused materials in their business. Stakeholder integration in terms of value chain integration is essential to succeed with the design of circularity in the construction industry. This results in an understanding within the stakeholders that circularity is developed throughout the life cycle of the construction project. Moving towards a circular construction industry forms new actor involvement and relationships. The third core element implies changing to circular thinking through the whole life cycle of the construction project, from the beginning to the end of life. Reused materials is a part of both the beginning and end of a construction project. In the beginning it should be considered as a substitute to virgin materials, and the project should be

designed and constructed with the purpose of reusing materials after the end of life of the property. The value proposition of the construction company and suppliers should correspond to the agenda of circular economy. The last core element is about understanding the end of life of materials in the construction project and to close the loop of the materials. 3R strategies, reduce, reuse, recycle, are important tools in the circularity. The construction industry mainly focuses on the "R" strategies recycling and reuse (Yang et al, 2022). There should be a shift of focus from recycling and waste management to life extension by reusing the material. This will transform the construction industry to a higher level of circularity. Reverse logistics is important to focus on as it facilitates the reuse of materials (Dewagoda et al., 2022). Included in circularity resource management, it is also essential to change the focus from demolition to deconstruction to save the used materials.

The support elements are continuous circular assessment, information management, circular business models and technology development (Dewagoda et al., 2022). There are a lot of actors included in the value chain of a construction project, and the decision taken by one actor affects the other ones. Therefore, it is important with proper information management to coordinate the information between the different actors. Circularity implies increased collaboration, and to manage the information contributes to increased traceability of information, and transparency when exchanging information. Circular business models are a key point when transforming the construction industry towards circularity. Stakeholder engagement, inclusiveness and integration across the supply chain are essential to consider when creating business models promoting circularity. Circular value proposition in combination with new stakeholder relationships are of highest importance when developing circular business models. Dewagoda et al (2022) mention product service systems as a facilitator when transforming to circular business models. This implies leasing, buy-back and take-back concepts of materials to ensure the materials will be reused. To succeed with circularity in the construction industry, existing business models should be redesigned, where governmental incentives and procurement reforms play a key role.

3.2 Industrial network approach

The industrial network approach (INA) provides an extensive framework for understanding the relationships and interactions between firms within an industrial system (Axelsson & Easton, 2016). In contrast to traditional economic models that treat firms as independent organizations engaging in isolated transactions, INA highlights the interdependencies that defines firms' behavior and decision making within a network. This approach is particularly useful for assessing complex interactions between actors in an industry. INA consists of three core components: Actors, Resources and Activities, the ARA model. The actor component encompasses the firms or organizations involved in the industry. Actors exchange and utilize resources within the network both tangible and intangible means to perform activities.

Activities occur in the network in the shape of processes and interactions that transfer or transform the resources.

The approach acknowledges that the three core elements, actors, resources and activities are connected, dynamic and constantly evolving through interactions within the network structure (Axelsson & Easton, 2016). These relationships strengths and nature determine not only the success and stability of particular firms but also effect the whole industrial system. Shifting the focus from isolated transactions to understand the dynamic nature of networks, INA contributes valuable insights into how networks innovate, allocate resources and competitive strategies. By positioning industrial networks as the main unit of analysis, firms may leverage their position with the network by using INA to acquire competitive advantages, foster innovation and reduce uncertainties. Considering the network as dynamic and evolving, searching for stability in the network is contradictory, however, stability is deemed vital for industrial development. The model is presented in Figure 4.

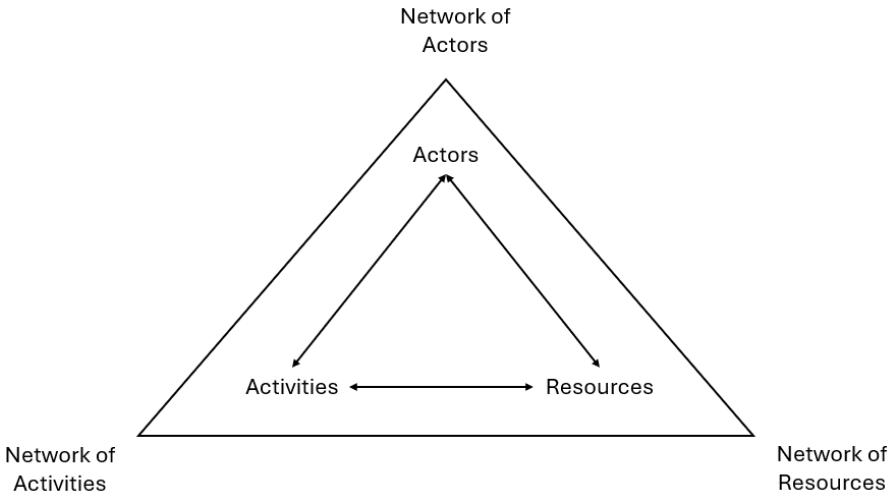

Figure 4: Adaptation of ARA model (Axelsson & Easton, 2016).

3.2.1 Actors in the industrial network approach

Actors control activities where they utilize resources that also may be in the actors' control (Axelsson & Easton, 2016). Individuals, groups of individuals, parts of firms, firms and groups of firms are all possible actors. Therefore, actors exist at several levels in organizations. Actors are defined by five characteristics, firstly, they conduct and control activities. Secondly, exchange processes create relationships between actors. Thirdly, actors decide their activities based on the control over resources. Fourthly, actors strive towards goals. Lastly, actors possess differential knowledge about other actors in the network, activities and resources.

Actors decide, either individually or collaboratively, which activities to conduct and how these activities should be performed. They also determine which resources to use when conducting the activities (Axelsson & Easton, 2016). The extent of access to other actors' resources is determined by the strength of the relationships within the network. Additionally, the activities depend on whether resources are controlled directly or indirectly. Direct control refers to ownership, while indirect control is based on relationships with other actors and the entailed dependence on them. The extent of indirect control is influenced by the dependence of the actor with ownership on the focal actor. Knowledge is also considered a function of control, shaped by the constraints of ownership. The presence of several levels of actors creates uncertainty about who owns which resources. This uncertainty affects the foundation for actors, as their general aim is to increase control within the network. The belief is that control can be leveraged to achieve individual goals (Axelsson & Easton, 2016). Furthermore, network control is achieved through direct or indirect control over resources, or over resources in combination with activities. Through experience, primarily from activities in the network, actors gain differential knowledge about activities, resources, and other actors in the network. They use this knowledge and their relationships with other actors to increase their control, as network control is not evenly distributed. While interests in the network are both conflicting and common, actors direct their efforts in alignment with their interests. However, an increase in control by one actor is always achieved at the expense of another actor's control, creating conflicting interests. At the same time, one actor's gain of control generally leads to a boost in control for another actor, thus establishing an extent of common interests as well.

3.2.2 Activities in the industrial network approach

Activities are categorized in two different groups, transformation activities and transfer activities, they occur when actors exchange, create, develop or combine resources by utilizing other resources (Axelsson & Easton, 2016). Transformation activities change resources in some way meanwhile transfer activities change the direct control over the resource from one actor to another. However, transformation activities are always directly controlled by one actor. Transfer activities connect transformation activities of separate activities to each other, thus, a transfer activity is never controlled by solely one actor. Furthermore, transfer activities affect relationships but are also affected by relationships between the actors involved. Several interdependent activities are repeated in activity cycles which are comprised of single activities, which are connected in various ways. A complete activity cycle consists of both transformation and transfer activities. Either specific transfer activities are conducted to facilitate certain transformation activities, or certain transformation activities are carried out to enable specific transfer activities. One actor never controls a complete activity cycle.

Activities in a network are coupled to each other in different ways and to different degrees, some are tightly coupled while some are loosely coupled (Axelsson & Easton, 2016). Tightly coupled activity cycles in an order compose a logical whole shape a transaction chain. In the

various activity cycles where an activity is a part of does not need the same regularity nor periodicity, some may be more frequent than others. Single activities are shaped due to the extent of dependency on the nature of the activity cycles as well as the transaction chain it is integrated into. Through experiential learning, routines and informal rules are created. This institutionalized form creates basic stability. Several relationships exist between the activities due to the tightly and loosely linked activities. Direct relations are present as a result of directly coupled activities, in contrast indirect relations are a result of loosely coupled via intermediate activities.

From the network perspective, single activities performed by particular actors are generally dispensable, they are in this context substitutable (Axelsson & Easton, 2016). As a result, the absence of one activity will not affect the network's function. This is possible because of the dynamic environment where surrounding activities are flexible and may overtake the function of the disengaged activity. Due to the dynamic nature of activities, where new activities may emerge, existing activities may evolve, or adjusted arrangements of activities can enhance efficiency, networks are fundamentally imperfect.

3.2.3 Resources in the industrial network approach

The resource dimension refers to the different attributes and characteristics of resources that influence their usage within various activity cycles and transfer chains (Axelsson & Easton, 2016). Resources are naturally heterogenous, implying they possess multiple attributes across an infinite number of dimensions. The dimensions represent the various ways in which a resource can be utilized, each dimension offers unique opportunities for application. The potential use of a resource is never fully or definitively specified, as new opportunities often arise when resources are combined or applied in different settings. The flexibility of a resource refers to its ability to be used across various activities and transfer chains, which is a key factor in its value. Moreover, the degree of standardization in contrast to uniqueness in how resources are utilized undertakes a crucial role. While some resources may be used in a standardized way across actors, others may be applied in more customized and unique ways depending on the specific needs of the activity or the actor controlling the resource. This variability in resource use, paired with the dynamic nature of resource combinations, highlights the complex and evolving nature of resource management in industrial networks.

3.2.4 Forces binding industrial networks

In an industrial network, actors, resources and activities are functionally interdependent implying heterogeneous demands from actors within the network are met through the exchange of heterogeneous resources (Axelsson & Easton, 2016). As an example, in a manufacturing network, different actors rely on specific materials, technologies or expertise provided by other firms to complete their tasks. Functional interdependence drives the need for coordination

among actors, as each actor's activities and resources depend on the actions of others. The degree of functionality in the network depends on the management of these interdependencies to meet the needs of all participants.

In the network, power relations are shaped by the control over resources and activities (Axelsson & Easton, 2016). Power structures surface when certain actors control critical resources or have the ability to manage certain activities. These actors may influence the network by dictating the terms of resource exchange or setting the standards for activities within the network. E.g. a firm with exclusive access to critical technology or resource may have more influence on decision-making processes compared to other firms in the network. Power structures in the network often shape the way activities are organized and may affect the strategic decisions by different actors.

Knowledge structure refers to how knowledge and experience are exchanged and shared within the network (Axelsson & Easton, 2016). The design of activities and the use of resources are influenced by the knowledge accumulated by actors. The knowledge of one actor may be related to, or shared with, others in the network, facilitating innovation and improvement. In industrial networks, knowledge sharing enabled firms to learn from one another, adapt to changes, and improve their processes. This shared knowledge may include technical expertise, operation practices, or market insights, all of which contribute to the overall performance and evolution of the network.

Intertemporal dependence emphasizes the role of history in shaping the network (Axelsson & Easton, 2016). The network's current structure and relationships are influenced by its past, including pervious investments in resources, relationships, and knowledge. This historical context means that changes within the network tend to be progressive, as they are built on the foundation of past experiences and decisions. For example, the relationships established in the past, the knowledge gathered over time and the resources invested earlier all influence how the network evolves. Therefore, changes within the network are often marginal, and large shifts tend to be closely tied to prior actions.

3.2.5 Factors shaping industrial networks

The actors' behavior toward change tends to be influenced by various factors, in particular, two variables affect change behavior (Axelsson & Easton, 2016). The competitive or cooperative context in which the actor operates within the network. The relationship of the change to the core activity to the actor.

When a change is proposed its closeness to an actor's core activity determines the likelihood of acceptance (Axelsson & Easton, 2016). If the change is outlying to the actor's core activity, the actor may be less willing to accept the adaptation. In contrast, if the change aligns with the actor's core activity, the likelihood of adaptation from the actor increases. If a firm is asked to

adopt a new technology that is closely aligned with its core business, they may embrace the change more than a firm that is asked to implement a change outside its core activities.

The relationships between actors within a network are often a mix of competitive and collaborative elements (Axelsson & Easton, 2016). The context of the relationship determines how the actor will respond to change. In a competitive context, actors are more probable to evaluate the change and may resist it, especially if it threatens their competitive advantage. Meanwhile, in a collaborative context, changes that are external to the actor's core activities are more likely to be transmitted to other actors in the network, as the actors work together to adapt to the change.

3.2.6 Implications for industrial network strategies

In industrial networks, strategy is not solely determined by individual firms. Rather, it evolves through interaction with other actors within the network. A firm's ability to execute its strategy is influenced by its position within the network and the relationships it has developed with other firms. For a firm to mobilize other actors in the network, it must have the ability to access and control resources. This includes having unique and limited resources, which can be mobilized to drive change within the network. A firm's competencies, the way it combines and utilizes resources, play a pivotal role in its ability to influence the network and drive change.

The strategic identity of a firm is formed by its relationships with other actors (Axelsson & Easton, 2016). This identity determines how the firm is perceived in the network and influences its ability to establish and maintain collaborative relationships. Strategic identity plays a central role in determining which actors are willing to collaborate and how resources will be allocated. Firms in industrial network constantly need to adapt to changes in the network, whether driven by new technologies, market shifts, or regulatory changes. Adapting to these changes is not an isolated process but requires collaboration and coordination with other actors. Adaptation is a continuous process that is shaped by the network's history and its actors' ability to respond to new opportunities and challenges.

4. Empirical data

According to a representative from a consultancy firm, the linear model of construction industry was created in 1970's, where efficiency became focus area. The goal was to produce as fast and cheap as possible. Before 1970's, the behavior was to take care of the produced material, contributing to extended lifecycle. However, there was a shift from maintaining products to replacing them with new ones, leading to properties being demolished and the materials disposed instead of preserved and renovated. During the last 50 years, the linear model of the construction industry has become streamlined and spent decades on optimizing its processes. The linear model consists of "take, make, use, dispose", where raw material is extracted, the material is produced, consumers utilize the material and then dispose it. The linear process can be seen in Figure 5.

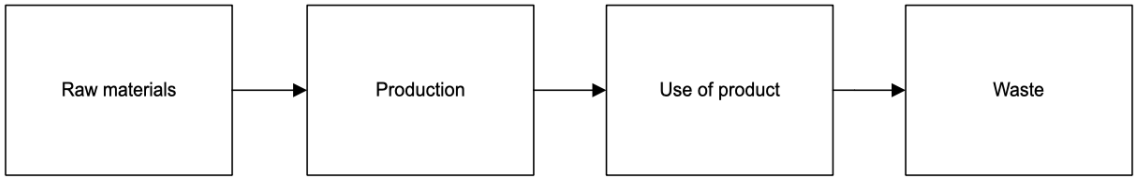

Figure 5: The linear model of the construction industry

The construction industry contributes to a lot of CO2 emissions, and to reduce the impact, it has over the years shifted towards a circular model focusing on recycling materials. However, the construction industry still generates large amounts of CO2 emissions, and the linear model is still used to the largest extent. To reduce the impact even more, the use of reused materials is an increasing topic. It implies dismantling materials in one property instead of demolishing and then using the materials in another property. According to several representatives, the reuse of materials is not contributing anything to the CO2 emissions, since the raw material has already been extracted, and the material has been refined. This emphasizes the importance of focusing on reused materials to reduce the environmental impact from the construction industry.

The market of reused materials is an undeveloped market and today it consists of initiatives from different actors on the market. Mostly, these initiatives are pilot projects. Actors have been working with reused materials only for a couple of years, indicating the lack of an industrial market today.

This chapter contains data collection from the 29 interviews. The chapter first explains three projects focused on reused materials. Secondly, the reuse processes of different actors are explained. The chapter then states the market drivers stated by the stakeholders in the construction industry. Furthermore, challenges and collaboration are described. The chapter ends by presenting the future of reused materials according to the representatives.

4.1 Projects focused on reused materials

In recent years, an increasing number of construction projects focusing on reused materials has been seen. This chapter present three projects, A, B and C. The aim is to create a holistic view of reused materials in the construction industry and to highlight success factors and challenges.

4.1.1 Project X

Project X was conducted between 2019 and 2022 and consisted of one property to be constructed. The focus of project X was to use as much reused materials as possible, and the tendering was made from carbon dioxide equivalents and requirements of reused materials. There were two main actors in the project, one property owner and one construction company. The construction company thought it was an interesting inquiry from the property owner, as they believe reused materials are the future. It was one of the first reusing projects that the construction company has undertaken.

The construction company had the responsibility to acquire materials for the project, and because of the requirements of reused materials, the process differed from the normal one. According to the construction company, one key factor when succeeding with reused materials is to find actors experienced in reused materials. This facilitates the process of finding the correct materials for the project. The construction company therefore hired a consultant for reused materials to help them find the materials needed.

"It facilitates working with people and companies who want to help and who are interested in reused materials." - Construction company B, R3.

The collaboration between the property owner and the construction company was a success. This was mainly because of the understanding for reused materials that the property owner had.

"The actors involved were willing to work for increased use of reused materials. The property owner was willing to do it. The operations on site were willing to collaborate to make it as good as possible". – Construction company B, R3.

Project X got materials from other projects, and other actors that the consultant of reused materials was in contact with. According to the representative of the construction company, finding reused materials is about timing.

"Currently, it's a matter of luck when it comes to finding materials. If we hadn't needed the plywood right then for another project, we wouldn't have kept them in stock." – Construction company B, R3.

Zinc panels were reused in project X. The consultant of reused materials received the request from a supplier of zinc, who had used the sheet metal at another project. The sheet metal was checked by the supplier of zinc and verified that the sheet metal had a life expectancy of about 25 years. The construction company had to pay a small amount for the sheet metal as there was value in it. The construction company decided how much was needed and bought it from the supplier of zinc. The material was delivered to a sheet metal worker who stored the material and cut it to the dimensions needed. The zinc panels were then delivered to project X, and the material that the construction company did not need was sold back to the supplier of zinc.

The prerequisites for storing materials close to the building were an advantage within project X. The property owner owns the land around the property, and the construction company could use the land to store the materials before being used in project X.

The construction company learned a lot from project X. Firstly, time becomes a factor. It often takes longer than expected to work with reused materials. Secondly, it is important to be quite open in the process because reused materials can change it a lot. According to the representative at the construction company, they should have found the material and then designed the building based on it. Now they solved it well because there were creative people involved in the project. An example is doors where the carpenters had to stand on the construction site and fix the door because it had been dismantled incorrectly.

"A general lesson from the project is that it would have been good to have the material experts involved earlier in the process. To test the idea with them before continuing with the material." – Construction company B, R3.

4.1.2 Project Y

Project Y is a large-scale new construction project spanning 40,000 square meters. It is still ongoing and plans to be done in 2027. The focus of the project is to use as much reused materials as possible. The initiative for reused materials within the project originates from the property owner, which aims to be at the forefront of sustainability, particularly in digitalization and reuse. Project Y is designed to scale up reuse efforts, which is a novel approach for new construction projects, as reuse is more commonly associated with renovation rather than new properties. Due to its size, the reuse process must be approached at an industrial level. Project Y also functions as a pilot project within a development initiative, focusing on digitalization and reuse.

Project Y consists of one property owner and one construction company as main actors. The construction company plays a leading role in project execution, coordinating all aspects of the building, including sourcing and installing components such as doors and windows. They manage procurement and engage subcontractors to carry out the construction work.

Currently, sourcing reused materials requires searching across various platforms, which is not viable for a project of this scale. The company envisions a scenario where suppliers can provide bulk quantities of pre-processed reused materials, such as 400 doors with standardized classifications and refinishing options, ready for just-in-time delivery.

Given the unpredictability of material availability, decisions on purchases must be made promptly. To accommodate this, the construction company has established a storage facility near project Y which the property owner will lease for material storage. The property owner rents the facility and hires a reuse hub to operate it. Several million Swedish krona are being invested in the storage facility, but the expectation is that the reused materials will be processed and delivered at a lower cost than purchasing new ones. A reuse hub is an actor who manages operations for several different reused materials.

"The more material that can be provided, the better the deal will be. Then the deal will go together and hopefully be a plus deal for us." - Property owner A, R12.

The property owner will consider using reused materials if the cost is comparable to new materials. While they can overlook warranties and replacement risks during the construction phase, financial viability remains a key consideration. From an investment perspective, they have limited funds available for working with reused materials.

The project operates within a collaborative framework, with multiple actors involved from an early stage. One of the strengths of project Y is the presence of dedicated and motivated stakeholders. The team of actors is working to establish a structured approach to reuse that can be replicated across the industry. Typically, reuse projects rely heavily on individual efforts, but in project Y, the aim is to implement a comprehensive strategy where the client actively demands reuse.

4.1.3 Project Z

In 2021, a property owner initiated project Z. Project Z consisted of a property of 10.000 square meters. Initially, they explored possibilities for repurposing and expanding the existing property, which was built with a heavy concrete frame. However, due to regulatory requirements and water level impacts on the property, renovation was deemed unfeasible, leading to demolition of the property. This led to a shift in focus, turning project Z into a reuse project. The primary objective was to determine how to maximize resource recovery.

An architecture firm was hired as reuse project manager and was their first large-scale initiative of this nature. The architecture firm performed together with the property owner a general reuse inventory check, to identify which materials could be reused internally and which could be redirected to other parties for reuse or recycling.

Furthermore, a demolition firm played a central role. They received an inventory check list and marked which materials they thought were worthy dissembling. Given the absence of urgency in dismantling the building, the contractor was able to work at a pace that allowed for careful material recovery.

"Thanks to the fact that we had so much time, actors were able to come and look at the material to see if it was something they wanted to use." – Architecture firm A, R1.

Various material recipients were involved, including other projects of the property owner that integrated reused materials. One such project utilized reused materials to construct an additional floor with a strong focus on reuse.

"One property in need of materials took a lot of material, which was grateful. They needed the materials the same time as we dismantled project Z. The timing was good." – Architecture firm A, R1.

Project Z contributed with a lot of reused materials. 35% of the windows were reused in a factory. 86% of the glass partitions were reused through reuse companies to private individuals. Some newer glass partitions were reused in local adaptations. 70% of the doors were reused, both inner doors, steel doors and entrance doors. A major part of it was reused through reuse companies to private individuals. Newer doors were reused in local adaptations. 36% of steel metal was reused. The facade metal sheet will be used in project Y, an initiative from the same property owner.

Supplier collaboration in the project primarily focused on recycling rather than reuse. A supplier of carpet tiles played a role by recovering carpet textiles, some of which were reused, while the rest was recycled. Despite these efforts, supplier involvement in reuse remained limited. There was significant potential for suppliers to facilitate the reuse of components such as radiators and toilets, which have long lifespans if properly maintained. Increased supplier engagement in the reuse process could have provided additional benefits, reduced waste and improving material lifecycle management.

According to the representative from the architecture firm, materials suppliers could do more, as they are specialists in their own materials. Several materials required some reconditioning, and the material suppliers should have the potential to develop their business model to include circular processes.

"Suppliers could have done a lot. For example, there were a lot of radiators, and they would have a long lifespan if they had been maintained. That is something that is difficult to do if you are not a supplier of them." – Architecture firm A, R1.

4.2 Process of reused materials

This chapter includes the process of reused materials. Firstly, the chapter explains the process of reused materials in a reuse hub. The, the process of a supplier's and wholesaler's point of view is explained. There exist two different types of suppliers within the reuse market. The first one is the supplier also producing new materials. These suppliers have developed their portfolio to also include reused materials. The other type of supplier is the ones only focusing on reused materials.

Each part begins with a material flow chart of the specific material, and then the process is explained.

4.2.1 Process of reused materials in a reuse hub

The reuse hub is a company and was created one year ago by a construction company. They focus on collecting and facilitating the work with reused materials in the construction industry. There are four people working at the reuse hub, and today the company possess one reuse hub. Figure 6 visualizes the process of materials.

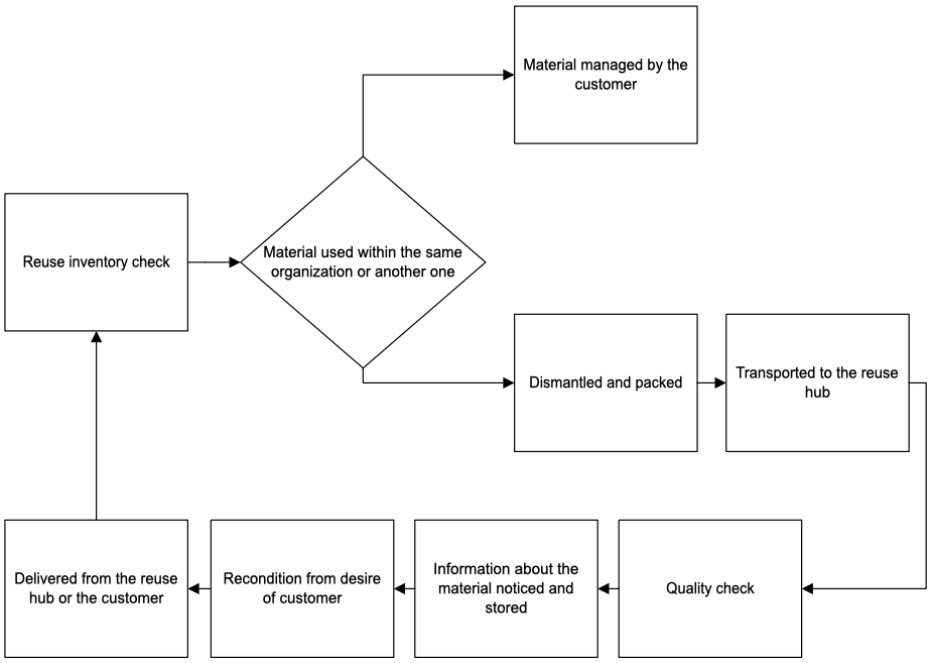

Figure 6: The process of reused materials in the reuse hub

Property owners contact the reuse hub when they are about to demolish a property. The first step is then to do an inventory check of what materials could potentially be reused. Representatives from the reuse hub perform the reuse inventory check.

Hopefully, the material can be used in another project within the same actor. The aim of the reuse hub is to not store the material at the reuse hub, but to transport the material from one property to another. In that case, the list of materials is sent to the property owner that can send it to their architectures and project managers. Then the property owner decides what materials they want to reuse, and the rest of it, the reuse hub can take to their warehouse.

If the material is not going to be reused within the same actor, the reuse hub brings the material to the warehouse. In that case, they are selective with what they take back. They only collect materials they know will be sold. The process after the inventory check is that the reuse hub sends dismantling guidelines of how to pack the material. This is a routine the reuse hub has developed.

Then, the material is transported to the reuse hub. Once it arrives at the reuse hub, the material is labeled with information about the material. The information is provided by the property owner. Necessary information differs among the materials, and for instance for doors it is important to mark it with fire protection and acoustics requirements. If the door is damaged somewhere, it is documented too. The reuse hub makes quality checks of the materials.

The reuse hub uses a platform to sell the reused materials. To be able to purchase reused materials from the reuse hub, the property owner needs to be a member. Not everyone can purchase materials from them. The membership is at no cost, but as a member you need to assure that you will contribute with materials, and also to buy materials. However, it is not stated how much. In many projects, the construction company is the one purchasing reused materials. The member is often a property owner, and the construction company then purchase materials in the name of the property owner.

When a purchase is done, the reuse hub tags the material with the name of the property owner, and the address where the material should be delivered. The material is then reconstructed from the desire of the customer. If the customer for example wants the door to be repainted, the reuse hub uses subcontractors.

"When we lack knowledge about the material, we contact suppliers. Those who produce ventilation products are an example. We don't know how to handle that, so we send those products to those who can. We can definitely get better at having more contact with suppliers, with those who have knowledge about the material." Reuse hub A, R16

Either the customer or the reuse hub delivers the reused materials. If the customer wants the reused material to be installed, the reuse hub uses the construction company.

When the reused material is sold, the reuse hub also provides the customer with reports of reuse. The reports consist of how many carbons dioxide equivalents the customer has reused.

"There is a lot of data, and that is what sells. Being able to see numbers on the footprint you make when using reused materials is important." – Reuse hub A, R16

4.2.2 Process of reused carpet tiles from a supplier of carpet tiles

The supplier of carpet tiles is a company selling different variants of floor. They started one year ago by focusing on reusing carpet tiles, and the process is visualized in Figure 7.

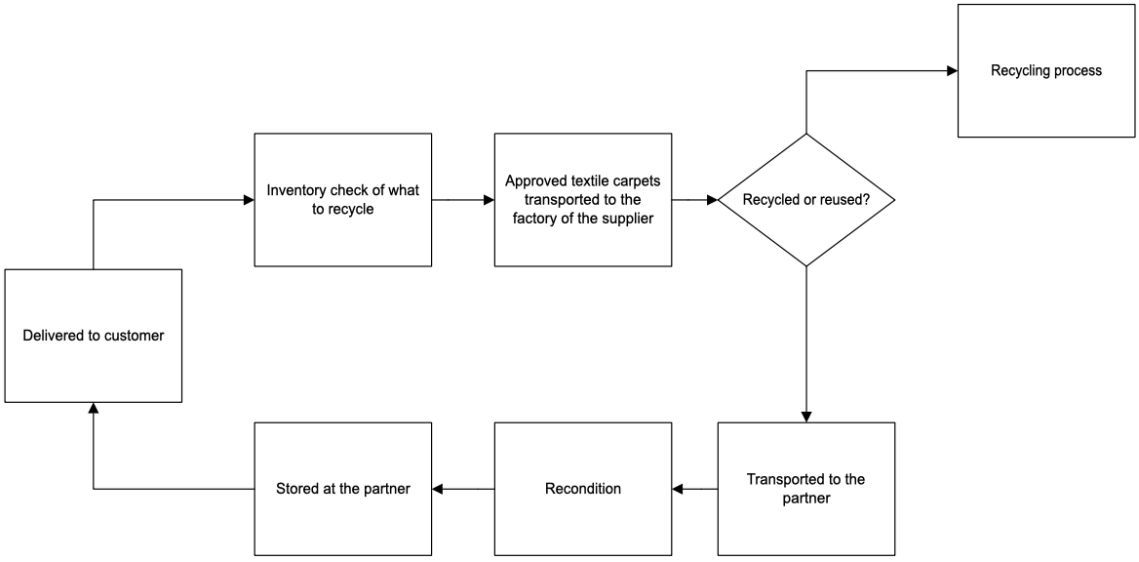

Figure 7: Process of reused carpet tiles at the supplier of carpet tiles

The process starts with the customer reaching out to the supplier of carpet tiles to get them picked up for recycling. As it is right now, the supplier of carpet tiles does not have the time to perform an inventory check of potential reusable carpet tiles on the property. They do an inventory check of what to recycle, and then the approved carpet tiles are transported to the factory, which is located outside of Sweden. The person who does the inventory could decide whether the carpet tile is approved for reuse, but that is not done today.

When the carpet tiles get to the factory, it is up to the personnel to decide what should be recycled and reused. There, they check how the carpet tiles look physically and if they look too fine to recycle, they reuse it. The selection is careful, and the tiles are quality assured. The reused tiles should look new, as they want to guarantee customers that they are tiles of good quality. The warranty is shorter for reused tiles compared to new carpet tiles.

Once the factory has decided which ones are to be reused, the carpet tiles are sent to a partner, who is also located outside of Sweden. They recondition the carpet tiles, meaning they are washed, and then packed into boxes. Then, the partner sells the carpet tiles on their website to property owners. If a property owner is interested in purchasing reused carpet tiles, they contact the supplier of carpet tiles, who sends a link to the property owner leading to the website of the

partner. The transportation is done by a transport company, but the supplier of carpet tiles pays for it.

When it comes to new tiles, everything is sold through flooring contractors, but when it comes to recused tiles, the carpet tiles are often needed quick, and they are then sold directly through the partner.

The recycling has not affected production in any way as the supplier of carpet tiles uses the partner who carries out the reconditioning. The sorting is done at the supplier of carpet tiles, but it is not something they have had to expand to adapt.

"We use our partner who carries out the reconditioning, because otherwise we would have had to change and rebuild our facility. We probably need a partner. I don't think we could have handled the reuse of carpet tiles completely ourselves." – Supplier A, R20.

4.2.3 Process of reused carpet tiles from a reuse supplier of carpet tiles

The reuse supplier of reused carpet tiles is a company started with the purpose of only focusing on reused carpets. The process of the material is shown in Figure 8.

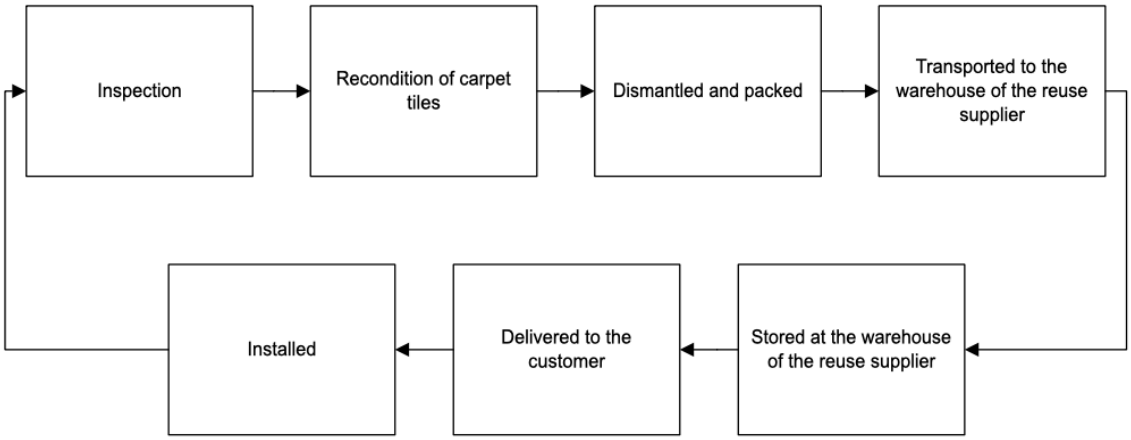

Figure 8: Process of reused carpet tiles at the reuse supplier of carpet tiles

The process starts with a phone call from the property owner or the construction company. It is often because there are requirements in the tender that a certain number of reused materials need to be used. The customer could have got the information about the reuse supplier as a potential actor to collaborate with.

A representative from the reuse supplier of carpet tiles inspects the carpet tiles together with a representative from the construction company. The supplier of reused carpet tiles creates a quotation for the service, and then the customer pays for it.

When the deal is approved, the reuse supplier of carpet tiles reconditions the carpet tiles by washing them before being dismantled. Washing them before dismantling makes it easier to see which ones are approved and not. Then, the carpet tiles are packaged and transported to the warehouse of the reuse supplier of carpet tiles. The reused carpet tiles are then stored at the warehouse waiting for purchase.

The carpet tiles are then sold, either through their website, or directly to customers they know need the reused carpet tiles. When the carpet tiles are sold, the property owner purchasing the service of taking care of the carpet tiles gets 30% of the price back.

The carpets are delivered by the supplier of reused carpet tiles, and the flooring contractor then installs the reused carpet tiles, the same way as new ones.

4.2.4 Process of reused glulam beams

The supplier of glulam beams has only worked on a project with reused glulam beams once, and the project is not finished yet. The process is visualized in Figure 9.

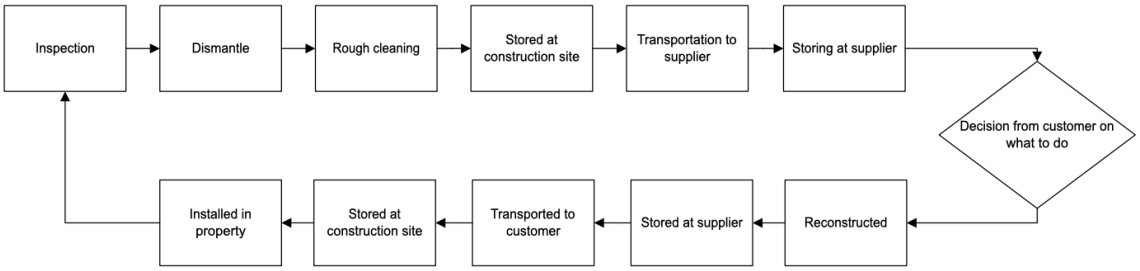

Figure 9: Process of reused glulam beams

They started their work with reused glulam beams with a request from a property owner, and it seemed interesting. The glulam beams were at that time used on the roof of an ice rink.

First, the supplier of glulam beams visited the ice rink for an inspection. They searched for rot, microbial growth (fungal attack), moisture content in the glulam, presence or traces of insects, presence of cracks and delamination (defective glue joints), presence of gaps and gaps, and obvious damage. The inspection was done before dismantling but can also be done after.

Then the glulam beams were dismantled by the construction company, and they did a rough cleaning of steel fittings, screws and nails. The dismantled beams were stored at the demolition site, and then they were picked up and transported to the supplier of glulam beams. They are now stored at the supplier of glulam beams, in the yard under a tarpaulin.

Now they wait for the desires of the customer. Then they will plan and remove the top layer to get new wood. Then they are reconstructed in the factory with CNC machines that drill, mill and saw according to detailed plans. They then install new steel fittings. Then it will be ready

for reused. The process of reused glulam beam is considered equal to the new one. The only difference is that with new glulam you store the raw material in a lumber stock and then plan the material. For reused materials, you start the process by planing the material, so you basically skip the first part of the production. There is no need to rebuild the production to manage the reused glulam beams.

The reconditioned glulam beams will then be stored at the supplier of glulam beams, until needed by the customer. The glulam beams will then be transported to the construction site and stored there until they are installed in the property.

4.2.5 Process of reused steel

The wholesaler of steel included reused materials in their sustainability agenda 2020, and recently they added reused materials as their newest product category. The process of reused steel is shown in Figure 10.

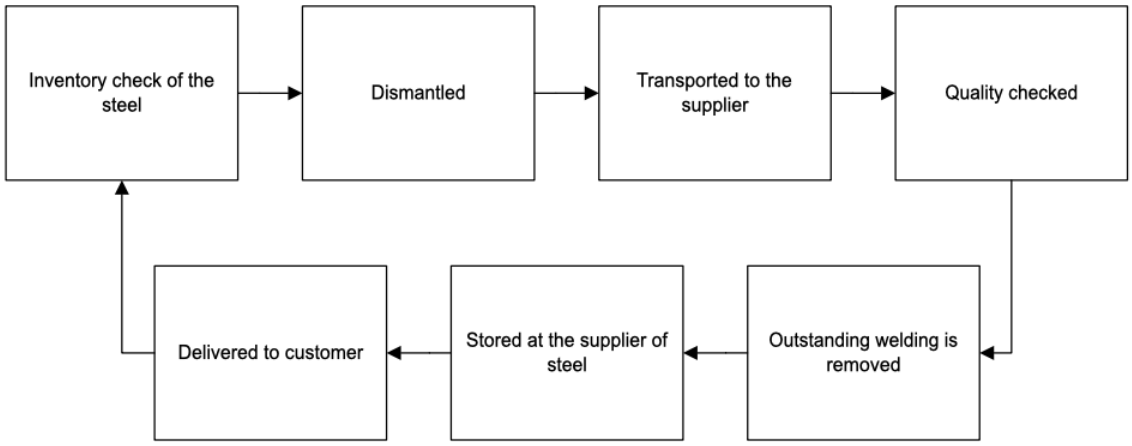

Figure 10: Process of reused steel at the wholesaler of steel

The process usually begins by talking to the customers of the wholesaler of steel, and the network of the customers. Representatives from the wholesaler of steel visit the building to do an inventory check of the steel.

"We can assess the steel by just looking at it." – Wholesaler B, R26.

Then, the steel beams are dismantled, and the wholesaler of steel picks the steel up. They usually do it through their already existing deliveries of new steel. The wholesaler of steel then performs a quality check, comparing it with the standard of the industry. It includes measurements to ensure they meet the correct shape requirements, and hardness measurements. That creates opportunities to map material properties. The measurements are summarized in a test certificate. If the steel possesses welded details, the wholesaler of steel removes them. They try to keep the reused steel as new, but if there are details on the inside of the beam, it remains.

Then, the wholesaler of steel stores it until it is ordered by a customer. When a customer wants to buy reused steel, it costs the same as new. On the website when ordering, reuse is listed as a category. When you search for a dimension, the reuse version is also shown as an alternative. If you go to a "new" steel, there is a link to get to the reused one. Deliveries are then made as usual by the wholesaler of steel.

The process of reused steel is almost identical to new steel.

"The industry standard that was released involved focus on integrated reuse materials. It means to try to keep as many processes as possible that we have today, because it works. It's the purchasing process that doesn't work the same for us today, but otherwise a lot does." – Wholesaler B, R26.

4.2.6 Process of reused installation products

The supplier of installation products has more recently focused on circular business models, with particular emphasis over the past year. The process of reused installation products is shown in Figure 11.

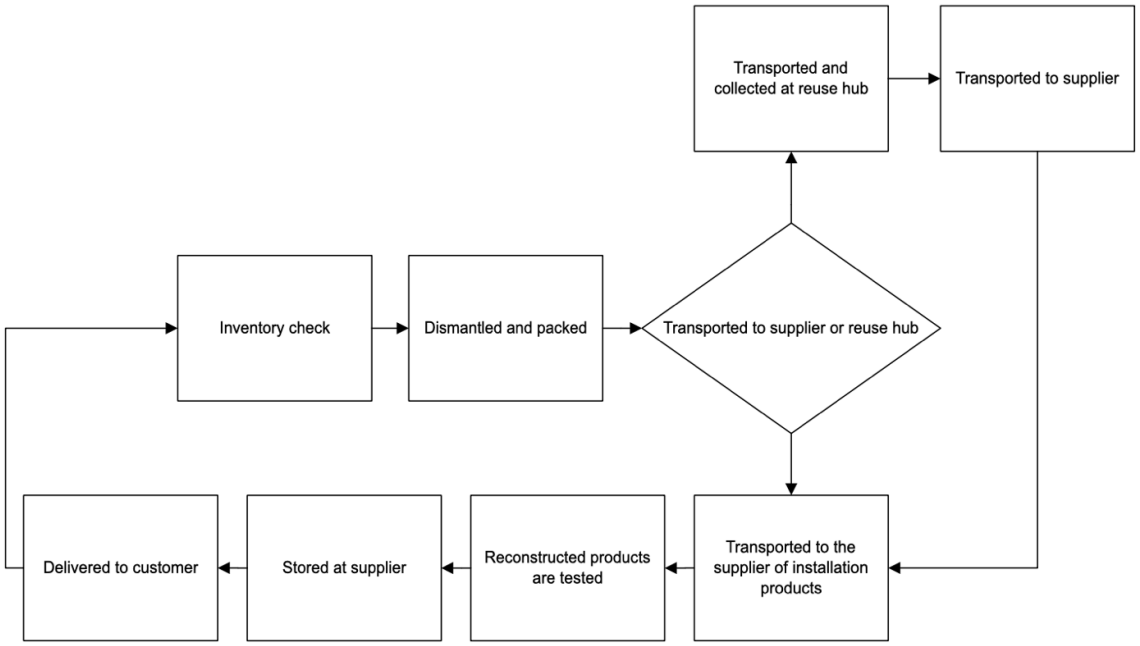

Figure 11: Process of reused installation products

The process begins when a customer or another party informs the company that a product needs to be returned. An inventory check is conducted, either by the company or an external party, to determine which products are suitable for reuse.

Next, the selected products are dismantled and packaged. Customers can choose to send the products directly to the company or via reuse hubs the supplier of installation products collaborates with. Even if sent to a hub, the materials eventually reach the supplier of installation products.

Communication within this process varies. Sometimes it occurs directly with the customer, while in other cases, it is managed through the reuse hub. Direct customer communication is often preferred, as it allows the supplier of installation products to track the history of the product and assess potential contamination risks. Being involved early in the process enables better decision-making regarding what can and cannot be reused.

"It is easier for us to have direct contact with the customer, because we would like to map out where the product has been and whether there is a risk of hazardous substances. It definitely makes it easier to be involved in the project early on." – Supplier D, R23.

Once the returned materials arrive at the company, they undergo processing. The recondition process differs from traditional production. Products are cleaned, updated, and certain components, such as fans in air handling units, are replaced with more energy-efficient versions. The products are then subjected to tests, including assessments for airtightness and pressure loss.

Unlike the traditional production of the company of installation products, which follows an automated assembly line, recondition requires a more manual workflow. This necessitates operational adjustments. Due to the level of customization involved in reused products, integrating them into the standard production flow is challenging. Therefore, the company maintains separate input and output flows for reused materials.

"We believe that there is a fairly low probability that it will match the exact same customer needing the exact same product in another project. In that case, we believe it is better to build a pool where it is possible to separately send back and purchase." – Supplier D, R23.

4.2.7 Process of reused suspended ceiling tiles

The supplier of suspended ceiling tiles started their work with circularity 2021. At that time, they collected their suspended ceiling tiles and recycled them. In June 2024, they started to focus more on reuse, since they identified a lot of suspended ceiling tiles possessing too good quality to recycle. The reusing process is visualized in Figure 12.

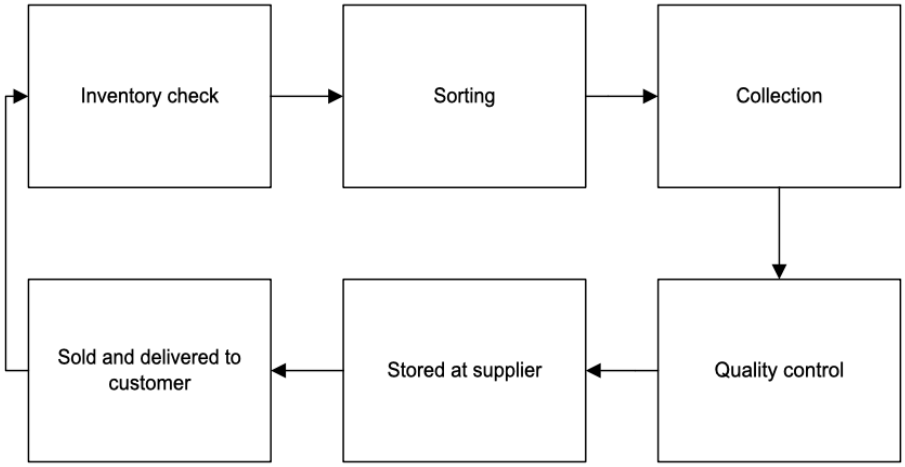

Figure 12: Process of reused suspended ceiling tiles.

The first step, inventory check, involves the company visiting project sites free of charge. This is done to increase their understanding and share knowledge with other stakeholders. Ideally, this assessment takes place either early in the project or right before demolition. In the future, they hope to eliminate the need for on-site visits by streamlining the process.

After inventory check, ceiling tiles are sorted into reusable and recyclable categories. In a typical project of 600 square meters, approximately 300 square meters can be reused. Some tiles are unsuitable due to installations or edge modifications, even though they may still be in good condition. Large-scale reuse is only feasible for standard tiles, as demand for non-standard ones is minimal.

To facilitate transportation, the company provides specially designed boxes, which customers purchase but later return. The company covers the return shipping costs and refunds the box price, aiming to reuse each box up to five times. Ceiling tiles are packed surface-to-surface to prevent dirt accumulation. Non-reusable tiles are placed in bags for recycling.

A detailed guide is provided to clarify acceptable damage levels. Demolition contractors, who have integrated reuse into their business model, typically handle the removal process. For smaller projects, builders or ceiling contractors may take on this role. Since cost efficiency is a priority, demolition contractors are often the most economical option.

Once packed, the supplier of the suspended ceiling tiles collects the materials at no cost to the project. Quality assurance is conducted using the same production lines as new materials, although currently, it is an expensive process. At present, inspections are carried out during maintenance downtime of the production line, but the company is seeking ways to make this process more efficient. Unlike some reuse initiatives, they do not refurbish tiles; they only perform quality checks to ensure the materials meet standards.

After passing quality control, the reused ceiling tiles are repackaged for sale. The company compensates customers at a rate of 30 SEK per square meter for approved tiles. This financial incentive encourages customers to opt for reuse rather than demolition, as dismantling takes longer than simply discarding the materials.

The suspended ceiling tiles are then stored until a customer purchases it.

4.2.8 Process of reused bricks

The supplier of reused bricks is a company focusing mainly on reused bricks. The process starts by involving themselves in the process of demolition of a property, to delivering reused bricks to the customer. The process of reused bricks is visualized in Figure 13.

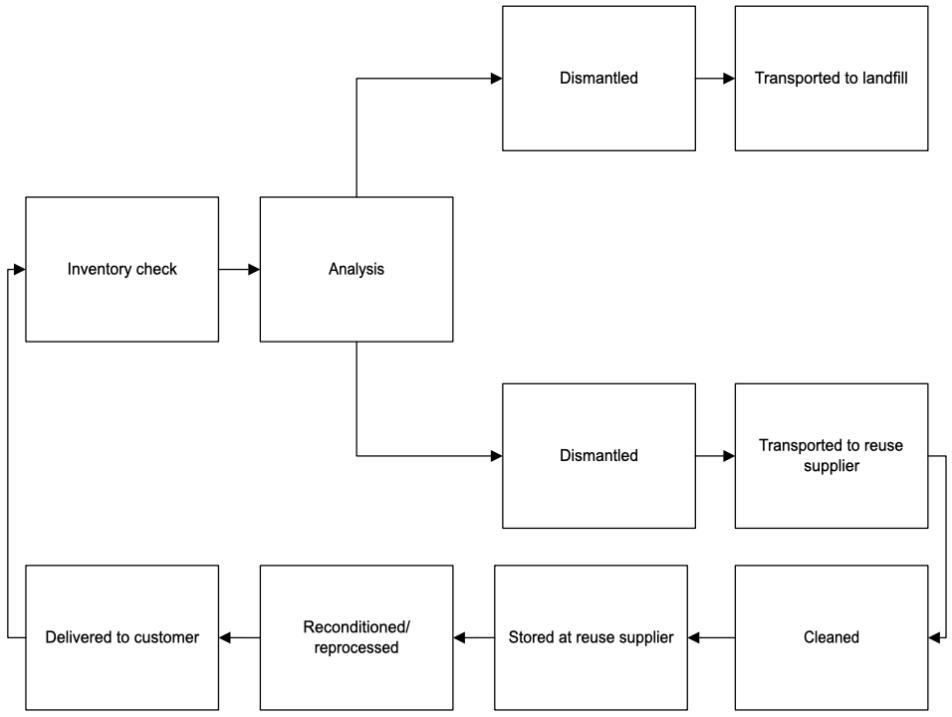

Figure 13: Process of reused bricks

The supplier of reused bricks has two separate flows of production, one for demolition and one for what is to be built. Those who purchase bricks should not need to worry about where they come from.

The process starts before the facility is demolished, when the property owner applies for demolition of the property. In the procurement phase, it is difficult to explain that the bricks should not be demolished. The supplier of reused bricks has therefore created procurement support to help clients to complete procurements with the right information. The supplier of

reused bricks has made a private and a public version, where it is clear and distinct what should be written.

After the procurement of service, it starts with a reuse inventory check. It is not a requirement today, but according to the representative it should be one. At that stage, the supplier of reused bricks visits the construction site and does a first quality check, to see if they find any visible damage to the bricks. Furthermore, they search for other factors affecting the bricks, for instance chemicals in the property. After the first quality check, they send 20 bricks from different places on the property to analyze whether they are approved to use as facade bricks. After the analysis, the property gets a batch number which explains information about where the bricks are from and what tests have been completed.

The property owner pays for the service of the first quality check and analysis of the bricks. If the bricks are approved for facade bricks, the supplier of reused materials pays back 3 SEK per brick. At first, they tried with a lower amount, but realized the customers disposed of the bricks instead since it was an easier and cheaper cost.

"Financial incentives are needed to get customers to choose to return used bricks." – Reuse supplier B, R19.

If the bricks are not approved as facade bricks, they can be used for other purposes, for instance indoor.

The process of the demolition contractor is the same, but the supplier of reused bricks complements the process with routines for taking care of the bricks without damaging them. The same means of transport is used when transporting the bricks to the supplier of reused bricks as to the landfill.

The bricks are then cleaned of dirt, and this is done in one batch at a time, to know all the time what bricks are being processed. The supplier of reused bricks also performs continuous tests to compare with the standard that exists on EU level. After the cleaning, they are stored until the customers place orders.

The production of reused materials consists of clearing the bricks from dirt, and mixing the different colors, according to the requirement of the customer. They make to order and plan production from that. The lead time for reused bricks is 6-8 months, compared to new brick which has a lead time of six months.

4.3 Market drivers

The market drivers for the reuse market are currently inconsistent and vary depending on the specific circumstances faced by different actors. This chapter aims to present the responses of various representatives regarding the factors driving the reuse market.

4.3.1 Environmental driver

The primary force driving the reuse of materials in the construction and real estate industry is largely aligned with the climate goals set forth by the Paris Agreement. Property owners, who are key stakeholders responsible for facilities and as clients in construction projects, face the challenge of minimizing their CO2 emissions.

The Paris Agreement, which was established in late 2015 by 196 parties during the UN Climate Change Conference (UNFCCC, 2025), is a legally binding framework requiring all involved parties to reduce their emissions in order to keep the global temperature increase below 2°C. As mentioned in Chapter 1, the construction industry is a significant contributor to CO2 emissions, prompting governments to pressure property owners to reduce their environmental footprints. A widely adopted measure among property owners to achieve this goal is the reuse of materials. This practice involves utilizing materials that are still functional and have not reached the end of their lifecycle, with the aim of dismantling, storing, and repurposing them in new facilities. The intention behind this practice is to reduce the demand for virgin materials and lower CO2 emissions. Several representatives stated that reusing materials does not add any CO2 emissions, the only CO2 emissions that are added by reusing materials is transportation. Reconditioning potentially adds some CO2 emissions as it is a refinement process requiring energy and resources to process the product or material. However, a majority of the representatives considered reuse to be a key activity in lowering emissions regarding construction.

Beyond property owners, the entire construction industry must also take steps to reduce CO2 emissions in alignment with the Paris Agreement. As such, it is imperative for all actors to adopt practices that support the reuse of materials in order to minimize their own emissions.

In Project Z, for instance, the property owner aimed to renovate a facility in a way that would keep CO2 emissions low and avoid demolition. However, due to legal constraints, the facility had to be demolished, and as a result, the property owner focused on maximizing resource recovery.

One property owner, responsible for both Project Y and Z, emphasized their commitment to sustainability in the construction industry.

"*We recognize our role as a major stakeholder and the significant impact we have in regard of environmental terms*." – Property owner A, R12.

Another property owner recently shifted their central strategy towards sustainability, with a strong emphasis on reducing CO2 emissions in both operations and construction processes.

"This drive for sustainability stem from passionate individuals within the organization and was later formalized as part of our company's strategy. A key goal of this approach is to minimize CO2 emissions, which naturally led to the incorporation of material reuse into our operations." – Property owner C, R14.

A supplier of steel also began incorporating reused materials into their business in response to the emissions associated with newly produced steel. Their 2020 sustainability agenda set the goal of including reused materials and Environmental Product Declarations (EPDs) in their operations. They now offer customers the option of reused steel alongside newly produced steel, aiming to reduce emissions in the steel industry.

Similarly, a supplier in the ceiling tiles market noticed that many of the suspended ceiling tiles removed during renovations were still in excellent condition and could be reused instead of discarded. This realization led to the launch of a reuse initiative, with the company striving to establish a future where reusing ceiling tiles becomes the norm rather than the exception.

One construction developer initiated a new construction project with the goal of reducing CO2 emissions by 50%. As a municipal construction development company, their primary motivation was to contribute to the creation of a sustainable society, with environmental concerns being the primary driver behind the project.

4.3.2 Business opportunity

The reuse market also presents financial opportunities for certain actors in the construction and real estate sectors. One demolition contractor noted that dismantling certain materials not only serves as an environmentally responsible choice but also offers financial potential by enabling the sale of these materials rather than disposing of them.

One supplier recognized the growing demand for reused products but also acknowledged their responsibility in providing sustainable solutions. This reflects a combination of both financial and environmental drivers.

"We want a comprehensive solution for property owners. We have been working with recycling for a long time and know that reuse is a step better. It also feels like a shame when too nice carpets are recycled that could be reused." - Supplier A, R20.

One property owner noted that reusing materials helped enhance their reputation and brand image. They believed that reusing materials made it easier to attract tenants, as sustainability is a key factor for many organizations. Another property owner, who also aimed to reduce emissions, noted that facilities built with a focus on sustainability were highly attractive to tenants. Similarly, a supplier of flooring materials mentioned that incorporating reused materials could serve as a competitive advantage in the industry.

Project Y, initiated by a major Swedish property owner, aimed to be a pioneer in sustainability, specializing in both digitalization and material reuse. The project's goal was to scale up reuse efforts for new construction projects, an approach that contrasts with the common practice of associating reuse primarily with renovations.

According to one property owner, their company had gained more confidence in their approach and improved its reputation in the industry over the past two years.

4.3.3 Market requirements

The interviews revealed that as property owners intensify their efforts to meet climate-related targets, they impose similar demands on their supply chains to align with these goals. This expectation creates pressure on other industry actors to adapt their competencies and update internal processes. All interviewed property owners reported requiring their collaborators to demonstrate the ability to work with reused materials. This, in turn, encourages suppliers and contractors to integrate such materials into their operations.

Beyond the initiatives of property owners, the construction sector at large is expected to contribute to the reduction of CO2 emissions in accordance with the Paris Agreement. The findings show a shared understanding among respondents that enabling the reuse of materials is becoming an essential step for all actors seeking to reduce their environmental impact.

"More and more companies want to be associated with sustainability, which is why there is so much interest in the reuse project. There is a lot of curiosity." – Property Owner A, R11.

The majority of interviewees expressed the belief that reuse practices will be a key component of the future construction industry. Many indicated that incorporating these practices is now seen as a necessity for survival in the industry. Consequently, actors within the industry are motivated to prepare for this shift, ensuring they do not fall behind as reuse becomes the norm rather than an exception.

One architecture firm explained that they support clients in the early phases of projects through feasibility studies and program planning. They also assist in setting goals and implementation plans. While traditionally focused on conventional architecture, the firm now offers services to integrate sustainable construction solutions from the outset. This approach led them to

incorporate reuse into their projects and evaluate whether structures should be demolished. In new projects, they design layouts with the intention of accommodating reused materials. The firm recognized growing customer demand for sustainability, which prompted them to add sustainability services to their practices.

A supplier of glulam beams began working with reuse based on a proposal from a property owner. They considered the project to be innovative and aligned with sustainable practices. However, they noted that they would likely not seek out reused materials as a business area but would rather engage in reuse projects where demand exists to fill gaps in their operations during periods of lower demand for new products.

Another supplier, specializing in ventilation solutions, emphasized their focus on circular business models. While they have always aimed to reduce operational carbon emissions, there is now an increasing focus on reducing embedded carbon. Market demand, driven particularly by green financing initiatives and regulatory requirements for climate calculations, is a primary driver behind their engagement in reuse. By proactively embracing reuse, the company aims to shape their business models rather than adapt reactively at a later stage.

"We are quite early in working with reuse because we want to have the opportunity to shape our models in a way that suits us instead of having to adapt urgently at a later stage." – Supplier D, R23.

4.3.4 Costs

Several property owners mentioned that material reuse plays a crucial role in reducing emissions. One property owner pointed out that reuse can also be advantageous for tenant adaptations, as it may shorten project timelines and reduce costs. Additionally, the disposal costs associated with waste materials are minimized because these materials do not need to be discarded. However, other property owners view reuse primarily as a requirement for reducing CO2 emissions, rather than as an immediate business benefit.

4.4 Challenges

Since the market for reused materials is still in its development phase, a lot of challenges exist. Some challenges are identified according to several actors, while opinions about some challenges differ among the actors. In some cases, representatives from different companies within the same actor disagree.

4.4.1 Matching demand with supply

One major challenge is the match of supply and demand. According to several actors, it is challenging to find a sufficient number of reused materials.

Representatives from the construction industry emphasizes that what is offered on the market also must meet demand. One example is indoor doors, which considers highly demanded in the reuse market. One property being dismantled may decide to reuse the inner doors, but once they start searching for demand there is no at that specific moment. It therefore results in throwing away the inner doors instead of keeping and storing them.

One of the challenges stated from a construction company's point of view is the supply of reused materials. In one project, the construction company planned on receiving a lot of reused materials from a property owner. However, the property owner saw the value of keeping it within their organization instead of sharing the materials. Considering this, the possibility of finding reused materials was minimized. An architecture firm focusing on reused materials also states that clients often prefer to manage reuse within their own organizations rather than sourcing materials externally, limiting market growth.

"Earlier it might not have existed a great supply. Now you are starting to apply pressure more and more on reaching the supply, but it has the opposite effect, instead the supply is shrimping because actors are saving the material inside the organization instead." – Construction company B, R4.

From a supplier's point of view, the demand is bigger than the supply, and to get access to the already used materials is challenging. The representative from a supplier of carpet tiles emphasizes the demand for reused materials as bigger than the supply.

"It is difficult to find the best way to get access to the used carpet tiles." – Supplier A, R20.

Furthermore, the representative from the supplier of installation products agrees. There is high demand for reused products, but relatively few customers return products to be reused. Accordingly, representatives from the wholesaler of steel states on of the main challenges as getting access to the steel.

The supplier of suspended ceiling tiles finds matching the supply with the increasing demand as a challenge. There are a lot of actors requiring reused materials, and it is usually about large volumes. However, it is difficult for the supplier of suspended carpet tiles to match that demand. Another obstacle when finding reused materials for one customer is the volume from one project may not be enough. For instance, for a 100-square-meter demolition project, only about half of the tiles may be reusable. This means that to supply one construction project, materials may need to be sourced from multiple demolition sites.

"We want to be able to meet the demand for ceiling tiles in the quantity requested, but the challenge lies in obtaining the material."- Supplier E, R24.

To match supply with demand is according to several actors time consuming today, and not sustainable for the future. According to some construction companies, a significant amount of time is spent searching for materials, to match their demand with the supply. A lot of time is spent searching for reused materials compared to new materials.

"We don't want to spend all the time we currently do searching for materials." – Construction company A, R2.

4.4.2 Traceability

Traceability is another challenge, implying knowing where products potential to be reused are originally from. There are several factors affecting the traceability of the reused materials. According to the representative of the supplier of installation products, a lot of actors handling the products is one factor. The supplier of installation products often sells to installers, who then resell to the property owner. Over time, ownership changes make it difficult to trace installed products. Many property owners also lack accurate records of the products in their buildings. This lack of documentation is a major obstacle to the reused market.

"We have tried to match our delivery addresses with the property addresses and found some matches, but it doesn't work in all cases." – Supplier D, R23.

Property owners agree traceability is a challenge in the reuse market. Tracing reused materials requires significant administration and coordination. Ensuring that project designers incorporate the correct materials is important for smooth processes in the reused supply chain.

The administrative processes are also stated as a challenge from a wholesaler's point of view. According to representatives, there is a need for clearer systems to track reused materials to facilitate their integration into the supply chain.

4.4.3 Logistics

According to most of the representatives, the logistics of reused materials remain one of the biggest challenges to large-scale reuse market. A company supporting property owners by offering a digital marketplace for promoting their reused products, states the importance of focusing on logistics to create a successful market of reused materials. According to them, the logistics of material reuse are currently challenging, especially for larger organizations operating on a national or international scale. Efficient logistics, including storage, transport, and establishing robust systems, are necessary to ensure that the process remains sustainable and cost-effective. Several representatives agree on logistics being a major challenge, especially when it comes to large organizations.

Storage is one challenge within logistics. For the actors already possess storage possibilities, the challenge is to find the capacity. For actors not involved in storage since before working with reused materials, the challenge is to find storage facilities. The demolition firms are an actor not possessing any own storage facilities. One demolition firm is looking into the possibility of storing, but they would rather not store materials since it can hinder them from getting rid of materials.

The storage of reused materials is considered a challenge according to the representative of a reuse hub too. It is easy to fill the storage with materials that no one purchases. For instance, if there are 15 doors, but one customer only needs 10, what to do with the other five? To manage that, it is important to collaborate with other actors to be able to sell the remaining materials to private customers.

The representatives from a software supplier state the suppliers as an enabler for simplifying logistics. They emphasize the need for reliable storage solutions, such as having a designated warehouse for reused materials, which would make it easier to manage the flow of goods and reduce storage costs. A representative from a consultancy firm also emphasizes suppliers to take responsibility for logistics, creating networks to collect and distribute reused goods. Additionally, they should be responsible for storage and sell these materials with a "reused" label in their regular distribution channels.

Representative from a construction company agree suppliers as enabler for the logistics.

"Material suppliers should be able to see business opportunities in simplifying logistics and integrating reused materials into the existing supply chain, as suppliers typically manage transportation for new materials." – Construction company A, R2.

From a supplier's point of view, opinions on logistics differ. According to the supplier of installation products, storage capacity is a concern. Currently, return volumes are low, but if they increase, storage costs could rise significantly. This introduces risks related to turnover speed. Unlike new production, which operates on just-in-time principles to minimize inventory, reused materials may require different stock management strategies.

Furthermore, the supplier of installation products emphasizes logistics as presenting several difficulties, particularly regarding reverse supply chain management. While the sales process for reused products mirrors that of new products, ensuring smooth return logistics is more complex. Once dismantled, products often require immediate collection. This necessitates having transport available at the right time and place. Additionally, transport providers require precise information on package size, weight, and quantity, which must be communicated in advance. Packaging material is another issue. Sending excessive packaging materials to dismantling sites is neither cost-effective nor sustainable. Furthermore, the supplier of installation products also explains the logistics for customers as a challenge.

Many different suppliers provide materials for a single project, yet only a handful accept returned products for refurbishment. This creates logistical complications for customers managing multiple suppliers and return processes. – Supplier D, R23.

The supplier of glulam beams considers logistics as not challenging. Today, there are according to them no logistics challenges regarding reused materials. The supplier of glulam beams uses the same processes for reused materials as for new ones. The only difference is the finger jointing and gluing is not needed when working with reused materials.

One of the wholesalers also sees challenges with logistics. The company is still in the early stages of figuring out how to make these processes work smoothly at a scale.

"There are significant logistical challenges involved with reusing materials, particularly around how to handle, store, and transport reused materials." – Wholesaler A, R25.

4.4.4 Costs

Today, the market of reused materials often implies high costs, and it is not financially profitable. Even though the reused material itself in most cases does not cost more than new material, there are other costs leading to increased total cost. There is no standardized cost procedure today for any reused material. It is also difficult for the actors to decide who should take the extra costs added when reusing materials.

For one property owner, it currently bears the costs of deconstruction, storage, and transportation, only to face higher installation costs and a lack of warranties.

"If reused materials can be supplied at cost parity with new products, adoption rates will increase significantly." – Property owner A, R12.

Another property owner agrees. When they find a material, even if it is free, there are additional costs for processing, storage, and quality assurance. The representative highlights that working with reused materials often presents a financial risk due to the ad hoc nature of the process, with one material being handled at a time rather than having an actor that provides a comprehensive solution.

According to the representative of the supplier of installation products, economic sustainability remains a key challenge. The primary cost barrier is dismantling and inventory assessment, which is more expensive than traditional demolition. The question of who bears this cost remains unresolved. Property owners are often unwilling to pay, and if suppliers absorb the cost, reused products may become too expensive. Currently, property owners typically cover the costs, but there is no standardized approach.

The reuse hub is not a profitable business at the moment, but the opposite. The construction company that the reuse hub is created from, covers all the costs. They therefore do not earn any money from it.

One property owner started by outsourcing material inventory checks to external consultants. However, this proved to be expensive, and now the employees of the property owner are educated to conduct inventory checks internally, which reduces costs.

One property owner has found that it can only pay a maximum of 70% of the new material price for reused materials while still making the reuse process financially viable. Regarding material costs, the property owner states a significant reduction of 30-50%. However, the reuse of materials in larger projects is often still more expensive than using new materials, due to the extra costs involved in handling and transporting reused products that the property owner needs to pay.

"*One of the primary challenges is the cost of reusing materials, as it is often more expensive to dismantle, store, and transport reused materials compared to purchasing new materials.*" – Property owner C, R14.

A construction company emphasizes the challenges with increased costs leading to canceling project execution.

"*Ideally, the financial model for reused materials should align with that of new materials. If reuse significantly increases costs, project viability is threatened, making it difficult for clients to justify investments*." – Construction company C, R5.

Another construction company states the financial aspect as hindering reuse.

"*We will buy new materials if the cost of reused materials is not equal to new*."- Construction company B, R4.

According to a supplier of installation products, the extra costs depend on the value of the material.

"*Reuse is more feasible for high-value products, where additional costs can be justified. Lower-cost items, however, become disproportionately expensive due to the labor-intensive process. We have therefore limited the reuse scope to economically viable products*." – Supplier D, R23.

4.4.5 Warranty

Regarding the warranty of reused materials, most companies leave function warranty, that the material functions when installed. Since some actors manage reused materials not owned by

them, it is not possible to provide product warranty. According to several actors, the warranty becomes a non-issue since customers usually do not utilize the warranty of materials.

"*We have spoken to all our property owners and customers and found that it is a non-issue. If the customers go through all their purchases over the last 10 years, there is no one who has used the product warranty on anything, not even 1% of all purchases. There is no resistance from customers or inquiries about warranties.*" – Reuse hub A, R16.

"*The question about warranty is discussed more seldom. The result of discussions is that we barely use the product warranty for new materials anyway, so we probably wouldn't need to use it for reused materials either.*" – Property owner D, R15.

The question about warranties is one challenge that the representative of a consultancy firm has identified. When you install a material for a couple of years, then as a customer you want to have a warranty that they remain for that amount of time.

"*For reused materials it is not as easy to set warranties.*" – Consultant C, R9.

According to the representative of a supplier of installation products, a fundamental aspect of the company's reuse strategy is offering a new warranty on refurbished products, as market feedback indicates this is crucial. The supplier provides the same warranty for reused materials as for new ones. This is possible because the manufacturer understands the necessary refurbishment steps to ensure increase product lifecycle. Ensuring warranty coverage and extending product lifespan are critical success factors.

According to the representative of the reuse suppliers of reused carpet tiles, it is not possible to give warranty of a product that they do not manufacture as new. However, it is not seen as a big challenge in the industry.

"*Since we haven't produced the carpet tiles, we can't give a product warranty. All the carpet tiles we work with, we can guarantee that they will last another 15 years. The warranty issue has been raised a number of times, but it hasn't been a priority in the industry. I think it would stop the development of the market a lot if you started to use warranty requirements on the materials.*" – Reuse supplier A, R19.

The representative from the architecture firm rise concerns regarding the warranty. Clients require clear assurances on which reused materials are covered under warranty agreements, as uncertainty in this area can hinder broader adoption of reuse practices.

4.4.6 Knowledge gap and mindset

According to several representatives, the knowledge gap and mindset of different actors is a challenge. The actors in the market consider the reused materials as second-hand, and therefore not as good as new materials.

"*You need to look up a little to realize that this is not second-hand.*" – Reuse hub A, R16.

According to the representative of the reuse hub one of the major challenges is the low level of knowledge existing within the market. The whole industry needs to understand what reuse is about.

"*One must recognize the potential in materials and improve expertise in this area. I am optimistic that knowledge and awareness will continue to grow.*" – Reuse hub A, R16.

It is important that the knowledge is built across the entire supply chain, and not only at the end of the supply chain as it usually is today.

"*There needs to be knowledge built along the entire chain, not just at the end of the workplace, as it is now. Often, everything is supposed to happen on-site, but in reality, it should start somewhere further back in the chain.*" – Consultant B, R8.

There is a need for interest in the reused market to be able to scale it up.

We need actors interested in reused materials and knowledge and experiences to be able to scale up the market for reused materials. – Property owner D, R15.

As stated by a reuse consultant, there is resistance to using reused materials, often due to uncertainty about their quality or a mentality that new materials are always better. This resistance makes it hard for both construction companies and property owners to fully embrace reuse, even when environmental and sustainability considerations suggest it is the best option.

Representatives from a wholesaler and software supplier emphasize the importance of changing behavior to be able to develop the market of reused materials. Success depends on people's willingness to adapt their behaviors and look at things from a different perspective.

"*The only challenges are the ones we encounter. A lot of it has to do with changing behavior. Everyone thinks reusing is good, but when it comes down to actually working with it, it's no longer as interesting.*" – Wholesaler A, R25.

4.5 Collaboration

According to several representatives it is impossible to handle the whole reuse process on their own. Therefore, collaboration between actors is crucial for the reused materials market in the construction industry.

4.5.1 Key stakeholders

As noted in 4.2, property owners are key stakeholders, consequently, they are crucial for driving the project's sustainability goals. As property owners can define the prerequisites for a project, they need to collaborate with different stakeholders in the industry. Property owners need to collaborate with a contractor who is responsible for the sourcing of materials. By structuring agreements, property owners can demand contractors to source reused materials. Contractors also need to collaborate with an actor that can supply them with reused materials. Since there are different actors that supply reused materials, their collaborators also differ between actors. There are different activities that need to be performed, such as storing, reconditioning, transporting, mounting, and so on. Suppliers of reused materials require collaboration with an actor that is dismantling a facility where they are able to receive material for reuse. Dismantling is an activity that often is carried out by a demolition entrepreneur or a contractor, on behalf of property owners who want to demolish a facility of their own. A majority of the representatives stated that collaboration is needed for the market of reused materials to function.

Reuse of materials is a way of sourcing materials that are unknown to current practitioners, leading to a process of much uncertainty. One way that the actors in the construction industry are managing the uncertainties is that they collaborate and try different approaches to discover a suitable direction. However, some consider that the collaboration between organizations to be dependent on highly enthusiastic individuals. The solutions vary between projects and the enthusiasm from individuals determine the successfulness of the collaboration, claims a reuse consultant.

Successful reuse processes required a close collaboration with subcontractors and architects throughout the project according to a project manager from a property owner. A partnership was established with a ceiling tiles supplier that offered both new and reused ceiling tiles. The property owner had materials able to be reused in storage which resulted in them needing help with the reconditioning mainly. This led to the property owner exclusively used the ceiling tiles supplier's services and not any of their competitors. The project demonstrated the importance of collaboration between developers and suppliers to refine the reuse process. It is, however, stated that no party made a financial profit from the collaboration, nor any financial losses. They benefited from the project in experience, as suppliers gained insights into potential reuse offerings and the property owner understood how suppliers may facilitate the process of reuse.

"*It facilitates working with people and companies who want to help and who are interested in reused materials.*" – Construction company B, R3.

4.5.2 Supplier involvement

From the interviews, many different actors have stated that the involvement of suppliers in reuse is limited. There are some suppliers offering reused materials, but the majority of suppliers do not offer to take their products or materials back after they have served their purpose in a facility. Neither do they offer a service to recondition products for purposes of reuse. With the current market, there are many smaller initiatives that are supplying the current need but when the actors try to reuse materials to a greater extent it becomes problematic. Many representatives have stated that it is problematic to come across greater volumes of materials to reuse. Furthermore, some representatives have stated that there is a wish for suppliers to offer reused materials in their product portfolio. Currently, there are reuse suppliers and they facilitate the procurement of reused materials.

"*There are some reuse suppliers, and having more of them would simplify processes.*" – Architecture firm A, R1.

One reason why actors specifically are wanted to take part in the reuse market is their credibility concerning products and materials. It was stated by a researcher who focuses on the construction industry that there is more credibility to reused products if they are sold by the experts on the subject. They also possess the means to recondition the products as well as having the acquired knowledge regarding the product's future potential. One representative also considered the involvement of suppliers early in projects focused on reuse could benefit the project.

"*A general lesson from the project is that it would have been good to have the material experts involved earlier in the process. To test the idea with them before continuing with the material.*" – Construction company B, R3.

Property owners are the ones initiating the projects and determining the requirements, they are creating the framework regarding the project's process and goals. Commencing a project heavily focused on reuse consists of challenges, but property owners are the customers and therefore sometime lacks the means to handle a reuse process. It is out of their scope to handle the business of selling and procuring reused materials and considers there to be a need for an actor in the industry to take responsibility. A sustainability manager from a property owner claimed suppliers possess the tools to sell products or materials.

"*We don't want to be the one selling and buying materials. We are a property owner, and it is not our core business to be a broker of reused material."* – Property owner D, R15.

Different actors working with reused materials are in contact with suppliers regarding what way suppliers can assist with reuse. However, there are complications concerning communication. Property owners are currently participating in the reuse process, and handle communication with suppliers, this demands resources and time that they cannot offer on a long-term basis.

"*We are in direct contact with some material suppliers today. In the future, this won't be possible. It would end up being too many actors for us as a property owner to have contact with. The process needs to include some other actor between us as a property owner and the material supplier*." – Property owner D, R15.

4.6 Opinions about the future of the reuse market

The majority of the representatives considered that the reuse of materials is something that will be present and practiced in the future. The last years all the representatives have seen a great growth in demand of reused materials. Many are convinced that the demand of the market will continue to expand, driven by the increased interest from property owners as well as other stakeholders in the construction industry. However, at the same time as the representatives consider the market to grow, they also recognize a lot of challenges and the market's early stage. Furthermore, a majority also regard a growth of the market as a necessity to convert the trajectory of the construction industry towards a sustainable path.

"*There is a need for change in the entire industry. Today there are only small initiatives in the industry, and that needs to change. The understanding that reused materials is good needs to increase.*" – Construction Company B, R3.

"*The industry also has a responsibility not to throw away new material. Many suppliers just want to sell new material today, but they need to work more on taking back and reuse materials.*" – Construction company B, R3.

Although reuse is viewed as important for a sustainable construction industry, the financial viability of the reused market is in many cases absent. The majority of representatives consider it essential to create a large-scale, self-sustaining, reuse market. Different representatives have expressed the requirement of creating a viable business model, where the critical issue to solve is finding who should pay for the cost of demounting. Representatives mostly think of reuse as an obligation and a necessary cost to establish a sustainable business. One representative thought this inquiry the key making the reuse market self-sustaining.

"*I would like to somehow shift the focus from seeing reuse as a duty to finding a business opportunity in it all. Then the interest in it will come. It's about finding keys to finding economics in it.*" – Property owner A, R12.

The representatives agree upon the state of infancy that the reuse market currently resides in. With the current growth in demand the representatives see the need to scale up the market, to match supply with demand. According to some representatives this requires that everyone start acting more circular and to accomplish that there is a need for coordination and collaboration.

"*The whole market must scale up in order for this to work in the long term, and that is exactly what is happening now. It is a fast transformation, but the need for coordination and collaboration is enormous*." – Property owner A, R11.

4.6.1 Suppliers' future role

Some representatives desire a market for reused material where it is as simple ordering reused material as newly produced. To scale up the market the use of the same channels would facilitate development greatly. In the future, it will not be sustainable to search actively for reused materials appropriate for the projects. Some representatives wish that manufacturers offer to take back their old products to ensure continued lifespan as well as function. As well as the processes, the suppliers have the flows in place to handle their materials for the purpose of reuse. Meanwhile, the representatives from suppliers' state that to start collecting the volumes need to be greater in order to have a viable business. Suppliers are according to the representatives the stakeholder in the best position with knowledge and expertise to assure quality and function.

"*By the same reason we don't buy materials directly from material suppliers today, we don't want to do it for reused materials*." – Property owner D, R15.

"*We need to be able to buy reused materials in almost the same way we buy new*." – Property owner A, R12.

Two representatives mentioned the importance of clear instruction for dismantling and safe packaging instruction for the materials' transportation. One reuse hub hands out dismantling instructions to the responsible personnel. One representative from the property owner declared desire that suppliers could also provide with instructions for dismantling for their products. They said that installation instructions often come with the products when you buy them, for reuse purposes the dismantling is as important as installation. Furthermore, the suppliers might not want to take back their own materials or products but with dismantling instructions they would contribute in some form.

"*Clear instructions for the dismantling and the packaging process should be available on their website, you should be able to easily access an instruction for dismantling. So that the material they are allowed to buy back after they have performed the dismantling and packaging, the supplier cannot withdraw from buying the material due to the reason that it was dismantled or packaged incorrectly.*" – Property owner C, R14.

Suppliers are urged to seize a more active role in retrieving and selling reused materials they have previously supplied. Many representatives highlighted the need for suppliers to accept returned products for reuse, refurbish them, and reintroduce them into the market. Some suppliers recognize the importance of offering reused materials but far from all, the representatives encourage all of the suppliers to incorporate a circular material flow.

"*I can't see how the construction industry can be transformed if we have all these reuse hubs with all the different materials. I believe more in our model as a materials supplier, that we should be able to take back the material that we have brought to the market. I see that more as a sustainable solution. Then we will be able to use it in a sustainable way*." – Wholesaler B, R26.

A representative emphasized the importance of collaboration between suppliers and other actors to create a cost-effective system for material reuse. While they recognized the challenges of involving multiple actors in tasks such as inventorying, dismantling, packaging, and transportation on construction sites, they suggested that a more streamlined approach, potentially through hubs managed by property owners, would be more efficient. The representative noted that managing their own reuse hub has proven cost-effective, as it allows them to inventory, dismantle, and handle materials internally, which is more affordable than purchasing reused materials from suppliers. Cost-effectiveness did not remain the same for all materials, some materials that were simple to handle, dismantle, store and assure function returned greater savings than more complex products and materials for them. However, due to high demand and limited access to materials, they also saw value in purchasing additional reused materials from suppliers to meet project needs.

"*It would be better for us to inventory, dismantle, and ensure the quality of the materials ourselves. With this method we have now, we achieve a more cost-effective process as we produce our own reusable materials*." – Property owner C, R14.

5. Analysis

The empirical data is analyzed by connecting it to the theoretical frameworks, answering the first research question. The analysis is conducted from the representatives interviewed from the construction industry.

To create a better understanding of the analysis, the subchapters are divided into actors, resources and activities, in line with the industrial network approach. The first two subchapters imply analysis of the projects, where all actors and resources exchanged were identified. The last subchapter includes the processes from the suppliers' point of view. Thus, it analyzes the activities in the market of reused materials today. However, not only the activities are presented, but also the actors connected to them.

5.1 Actors

When applying the ARA model on the data collected regarding the projects from interviews, it becomes evident that there are three main actors present in all three projects. First, the property owner, they are exclusively the customer and the ones determining the criteria for the projects. Criteria may be that a property that is to be constructed aims to lower carbon dioxide emissions compared to traditional construction. It may also be that a property that is to be demolished should be dismantled instead. Dismantling the building instead of demolishing it will enable the materials to become part of a circular flow rather than linear. The property owner is the customer and sets the aims for new constructions and owns the property that is to be demolished. Therefore, they are considered to be the enabler of starting a circular process of reusing materials. Moreover, in line with the collaboration tool, property owners are in the projects responsible for phase 1. Meaning that they are to set the circular vision for the project, responsible for shaping collective processes. In the network they are an actor that possess a high degree of control as they directly control the resource of the properties. Therefore, they are required to initiate the circular process.

In the projects where construction takes place, there is always a construction company participating. The construction company is the one responsible for using the reused materials and in one case they were also responsible for procurement of reused materials. Thereby, construction companies are considered a key actor in the process of reusing materials. In project Z, which is a demolition project of a property, another key actor appeared in the shape of a demolition firm. They were responsible for the recovery of the materials by dismantling them rather than demolishing the facility. The role of the demolition firm is also considered a key role in the process of reusing materials since without careful dismantling the materials may not be reused later on. After the dismantling process, the materials have to be stored and consequently transported to the location of the reuse or reconditioning. The role of handling

logistics has varied throughout the projects. In the projects, either recipients of dismantled materials or any actor with the capacity to transport materials managed transport. Storing has taken place either on-site or in a nearby storage facility that is rented for the project.

Another key role that was discovered was a coordination role. This coordination role has been carried out by reuse actors, in the shape of consultants, reuse hub and architecture firm. The goal of this role is mainly to bring knowledge and expertise but also coordinate the reuse processes of the projects. In project X the reuse actor also aided in the search for reused materials. Reuse hubs have also aided in the reuse processes by supplying dismantling guidelines to make sure that the materials are dismantled in a safe manner, keeping quality and function intact. Furthermore, the reuse hubs have stored materials on their own and if they consider material to be of adequate quality and function, they agree to reclaim the dismantled material. Consequently, they inspect the material to see whether it needs to be reconditioned or not and they also perform the reconditioning. When the reuse hub personnel are sure that the material is of needed quality and function, they post that the material is for sale through a digital platform with specifications on the material. Thereby, reuse hub manages some logistics in the processes they are involved with, they offer transport and storage to their collaborators.

Thereby, projects have resulted in the identification of four key roles but also other roles that are not specifically tied to one actor. Property owner as the customer, initiates projects, both construction and demolition projects, setting goals and requirements. Construction companies are responsible for constructing the new facility and incorporating reused materials in this process. They manage the practical part of the reuse of materials. For this process to be successful, a coordination role with experience of reuse has been necessary in order for projects to succeed. For materials to be reused, there is a need for a role that can dismantle the materials. Regarding the projects this role has been filled by a demolition firm. They are responsible for careful management of the dismantling process and packaging the materials to be safely stored and transported. However, there is a need for storage and transport as well, this role has not been occupied by one specific actor. Something that could have been interesting would be if the projects had involved an actor managing the logistics of the projects. This is to see whether the transportation and storing could have been managed in a more effective way.

5.2 Resources

The property owner controls different resources in the reuse processes. They are the ones owning the material when they have been dismantled and therefore controls how they should be reused or discarded of. By that logic, property owners have direct control over the start of a material's reuse process. Furthermore, when a facility is determined to be demolished, the property owners control the resource contract. In that aspect, property owners can control through contracts if materials should be placed in a circular flow or a linear one. By specifying

contracts, they control whether a facility should be demolished or dismantled, which can be seen as an enabling resource for the circular flow of construction materials.

In the projects the procured materials have mainly been sourced externally from the projects. Meaning that the projects did not dismantle materials and then stored in order for them to later be used in the construction, except for some specific cases. For project X, the property owner had in storage materials that had been dismantled in other projects that could be incorporated into the new facility. Also in project X, they procured zinc panels from another organization, but they did not reuse material within the project to a greater extent. Therefore, project X processes were aligned with scenario three and four from the AFRY report (Bosch et al., 2023). Project Y and Z are connected to the extent that some materials are stored from project Z to be reused in project Y. But the procurement process mainly searches externally for reused materials. Thereby, resource exchange in terms of reused material, ownership is often transferred between different projects and organizations. By that, the processes from project Y and Z also were similar to scenario three and four, with scenario four being the most represented scenario. This is similar to the way tangible resources are exchanged in a traditional market. However, it is often more complicated in terms of finding material, regarding both volumes but also finding it at an appropriate time. Procuring reused material has been a time-consuming process and there is a need for the process to be facilitated. Currently, there are actors that are contributing with knowledge and expertise in the processes to smoothen the processes, such as reuse consultants and sustainability coordinators from e.g. architecture firms. However, the process of finding reused materials and ordering it remains a complex and time-consuming process, although outside expertise is contributed.

Transportation of the material and storage has been done by truck similarly to the process of traditionally produced materials. However, for the projects there has been a need for one-time solutions regarding the packaging of many dismantled materials. There are rarely packing instructions for dismantled materials nor packaging materials, therefore they have had to improvise and find alternative packaging methods. Hence, the need for instructions regarding packaging as well as the supply of packaging material has become apparent. Currently, there are suppliers and reuse hubs that are providing guidelines for how to dismantle properly. But this is not a standard throughout the industry. Regarding dismantling, the actor responsible for that activity has to improvise how they can dismantle the material without damaging it. Instructions regarding how to safely dismantle to keep function and without damages appearing could facilitate the process of dismantling. When the materials carefully have been dismantled, packed and are ready to be transported either to storage or to end location, the question of recondition takes place. In the projects, all materials have not needed reconditioning. The materials that needed reconditioning were either reconditioned on-site as in project X or transported to an actor with the competence to recondition, supplier as an example. In project X the reconditioning was handled by the construction company which posed a challenge regarding finishing the project on time. However, there are suppliers and reuse hubs that also

perform reconditioning. They often provide logistical support in the shape of transportation and storage and inspect the material to see whether reconditioning is needed or not. Depending on the material's condition, reconditioning is performed by the actor who have reused the material. Another actor that possesses transportation resources is demolition firm that can facilitate the logistics furthermore.

In all the projects the tangible resources' material flow is in the reuse process similar to a traditional material flow. The activities that are conducted regarding logistics are comparable to the activities carried out for traditional linear flow. Some activities do however differ, such as inventory check, dismantling and reconditioning. Therefore, knowledge and expertise are resources that become valuable. As these resources are required, reuse actors quickly become of great interest as they can help coordinate the projects to make the process smooth.

5.3 Activities

One finding when analyzing the market of reused materials, is the miss match in demand and supply. When scaling up the market, it is important to involve several actors outside of one organization. This goes in line with the fourth scenario concluded from the report AFRY conducted (Bosch et al., 2023). Thus, the other scenarios presented limit the upscaling of the reuse market. If organizations decide to keep the materials within the organization, other organizations will not have the possibility to reuse those materials, limiting the upscaling of the reuse market.

By analyzing the selected processes of reused materials, findings are made implying several steps are included in several processes. However, it is important to have in mind that the empirical data does not cover all materials and all processes in the reuse market. From the empirical data, one general process appropriate for several suppliers can be created. There are steps similar to the regular processes in the construction industry, while some are added regarding reused materials. From the collection of data, one requirement from the industry is to keep the processes similar to the already existing ones. Therefore, one finding is that there are two different linear models within the circular model of the construction industry. One for dismantling a property, and another for constructing one. The processes added when working with reused materials will be deeper analyzed. These are inventory check, dismantling, packing, transportation back to the supplier and reconditioning of the material. All steps are presented in Figure 14, where the ones in the blue box are the new ones connected to reused materials. For each step, the most appropriate actor performing it is presented.

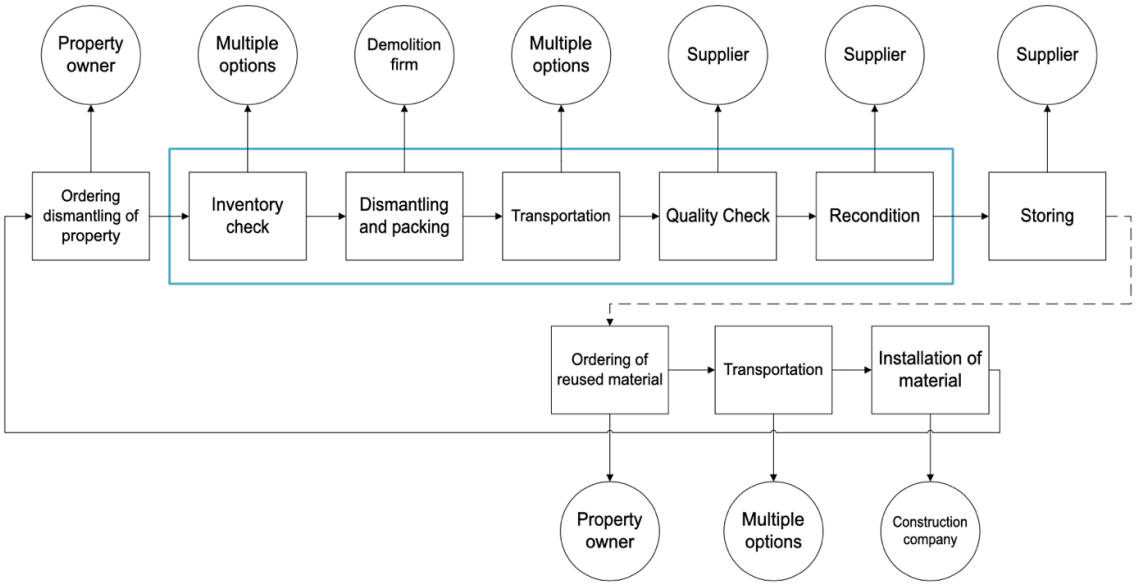

Figure 14: The main activities of reused materials. The blue square implies the processes added from the ordinary process when working with reused materials. For each activity, the connected actor is presented in circles.

5.3.1 Ordering dismantling of property

The first step is the property owner ordering a demolition of a property. This is the same as for a construction project not focusing on reusing material. This indicates the property owner as the initiator of the process. This could be connected to the collaborative framework, phase one. It implies the customer, in this case the property owner, is the one in charge of creating visions of circular processes in the construction project, with a focus on reused materials. Thus, the reality goes in line with the theoretical framework. However, the contract needs to be specified as a dismantle of property instead of demolition.

5.3.2 Inventory check

The second step implies representatives from all suppliers and the reuse hub visit the construction site and perform an inventory check. This is a new step regarding the market of reused materials. The representative of reused supplier of bricks argues the importance of conducting inventory checks, something not mandatory today in the industry. Inventory checks is therefore an important activity moving towards a more circular construction industry. Align with circular resource management and end of life planning as a core element in the design for circularity framework, inventory checks are a crucial early action that support material reuse and life extension. It is stated from the representative of a property owner that it is unreasonable for each supplier to visit the construction site and perform inventory checks. The supplier of suspended ceiling tiles aims at removing their part of the inventory check once the processes

are well developed. A lot of unnecessary time and resources will be utilized if each supplier performs the inventory check of their own material. Even though it is unreasonable for each supplier to perform inventory checks of their own material, they still possess the most knowledge about their material. Therefore, one suggestion is for the suppliers to create guidelines on the requirements needed for a material to be approved as reused. The guidelines should be available on the websites of the suppliers, which creates easiness in getting access to them. The guidelines emphasize on information transparency and traceability, which is in line with the support element of information management in the design for circularity framework.

The one performing the inventory check is to be further decided. In the projects, it differs who performs the inventory checks. In some cases, there were both reuse coordinators, property owners and demolition firms performing the same inventory check, and that is not efficient. It is very unnecessary for several actors to conduct the same inventory check. There are reuse consultants in the market, potential to conduct the inventory checks. However, representative from one property owner states the increased costs in hiring reuse consultants to perform inventory checks. Yet, this is only one opinion and in some cases the reuse consultant is the appropriate actor to perform the activity of inventory checks. The reuse hub performs inventory check on several materials since they gather more than one material type. The finding states the property owner most appropriate for the inventory check. Firstly, they have direct access to the property and its material. They also have the potential to know what material was installed during construction. Furthermore, they are involved early in the construction project. Since inventory checks is a part of the early stage of the process, property owners are involved from the beginning. It therefore enables proactive decisions on what to reuse before the dismantling starts. The inventory checks led by the property owner shows of collective mindset, which is included in phase two of the collaboration tool. Guidelines from suppliers implies standardized procedures, and the collaboration become holistic and coordinated, rather than siloed activities. Higher order learning is also identified when suppliers rethink their role. Not by executing the task themselves, but by enabling the property owner through knowledge sharing.

5.3.3 Dismantling and packing

Dismantling and packing the material is the next step of the process. This activity is controlled by the property owner, where usually the demolition firm performs it. This process is similar in all observed cases except for the reuse suppliers of carpet tiles. They perform reconditioning, in terms of washing the carpet tiles, before dismantling. However, the next main step of all processes is the dismantling part. One finding is the change in how to work for the demolition firm. It is no longer about demolishing the property in the fastest way, but to find ways on how to manage the material carefully to create prerequisites for reusing the material. This goes in line with the design for circularity framework, where acceptance is an important starting point. The different actors need to accept the adoption to circular practices, where it in the dismantling part concerns the demolition firms. This can also be connected to phase two in the collaboration

tool model, where the aim is to have a collaborative aim instead of separated. There is need for collaboration between property owner, demolition firm and supplier when dismantling the material. The representative from the supplier of suspended ceiling tiles states the importance of providing the demolition firm guidelines on how to dismantle the material. This is done by them and the reuse hub today. It therefore differs among the suppliers today whether they provide the property owner and the demolition firm any guidelines on how to dismantle and pack the material. The suppliers possess the most knowledge about the material, and one important activity for them is therefore to provide dismantling guidelines. The instruction should include how to dismantle and pack the material to facilitate the process of reusing it. These instructions should also be available online on the website of the supplier. To facilitate the packing process, it is essential for the supplier to provide the demolition firm packing material. To succeed with that, it is important with communication and planning to be able to provide the construction site with packing material at the right place and time. The supplier of suspended ceiling tiles takes a deposit for the property owner to pay when getting the packing material. This deposit is then paid back once the packing material returns to the supplier. This is a suggestion for other suppliers to use.

5.3.4 Transportation

The third step is transportation back to the supplier. The wholesaler of steel manages to take back material on the same transport as they deliver new material. The reuse supplier of bricks uses the same transportation modes but change the delivery point to their factory instead of the landfill. Other suppliers state the challenge with managing the transports of reused materials, as it today often needs to occur directly, with no heads up. To be able to manage the transportations of the reused material from one property to the supplier, there needs to be an increase in coordination among the different actors. This emphasizes the importance of stakeholder integration as a core element in the design for circularity framework since it tightens integration and alignment between multiple stakeholders.

There are three potential scenarios for the transportation of reused materials. The first one implies the supplier picking up their own material at the construction site. On one hand, this could lead to more traffic on the construction site, and insufficient load factor in the trucks. On the other hand, some suppliers already gather material to recycle, and the reused material is a part of that. In that case, the load factor would not be any issue. The scenario is shown in Figure 15.

The second scenario is a third party logistics provider managing the transports of material from the construction site to the different suppliers. The logistics provider picks the material from the construction site and then perform milk rounds to the suppliers. This scenario is shown in Figure 16. This would lower the traffic at the construction site. One potential drawback with

this is that the suppliers might be located on very different geographical locations, implying long and inefficient routes.

The third suggestion is to utilize a terminal where the material is stored until the suppliers picks it up. This is presented in Figure 17. The concept of the terminal could differ depending on the material and how the process for new material works today. For instance, the terminal can be managed by a third party logistics provider, storing the material until it is gathered from the suppliers. Another concept is the terminal as a wholesaler. If property owners order new materials from a supplier through a wholesaler today, them should oversee taking the material back, and then the material is transported from them to the supplier. The reuse hub could be seen as a terminal today, but the material is not transported to the supplier but stays at the reuse hub until a property owner needs it. However, the reuse hub could be developed towards a terminal between the construction site and the suppliers.

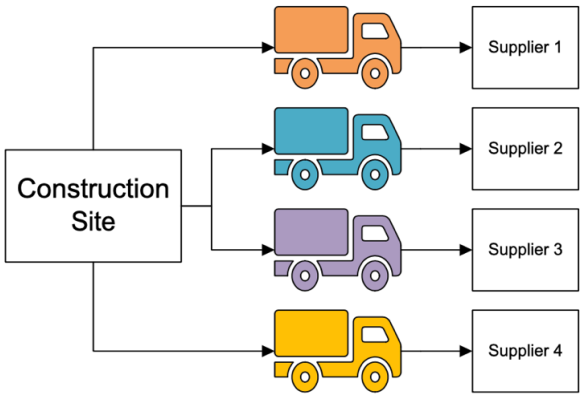

Figure 15: Scenario 1. Each supplier transporting its reused material from the construction site to the suppliers

Figure 16: Scenario 2. Using the same transport when transporting reused material from the construction site to the suppliers

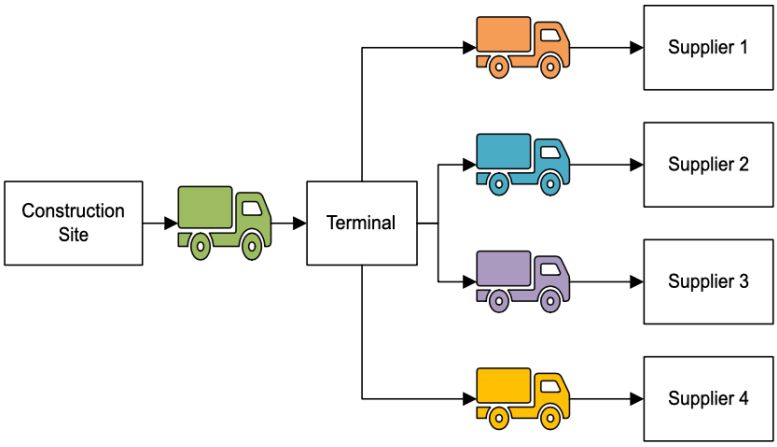

Figure 17: Scenario 3. The use of a terminal when transporting reused material from the construction site to the supplier.

Which scenario that is most appropriate depends on different factors, for instance geographical area and what material it is. The best scenario is the one most similar to the ordinary transportation of newly produced materials, but to reverse it. This could differ in the industry, and it is therefore important to choose the scenario most appropriate for each actor. No matter who performs the transportation of material, they need to be aware of potential material to be reused as soon as the property owner initiate a reuse construction project. Furthermore, this step is also connected to phase two of the collaboration tool. Once the property owner creates the vision in phase one, the suppliers or logistics provider need to be involved in phase two. This creates opportunities for the supplier to plan when to pick up the reused materials. Furthermore, information management as a support element from the design for circularity framework is essential to move towards a circular construction industry. Effective transport planning requires time and accurate information about when materials will be available, and a transport planning system is therefore needed.

5.3.5 Quality check

Once the material has arrived at the supplier, it is up to them to decide whether the material is in need of recondition or not. Some kind of quality check of the material is required, to decide the condition of the material.

5.3.6 Recondition

The next step is reconditioning the material. One finding is that the supplier is the one with knowledge about the material and therefore know the best how to recondition it. In this step, it is important for the supplier to adapt the production to manage the recondition of the reused materials. The representatives from suppliers state the difficulties in rearranging the production since it contains of high costs. Analyzing the interviews, the recondition concludes in one of

the most challenging parts. However, it differs depending on what material it is. For instance, the suspended ceiling tiles only need quality check and no further reconstruction. However, the quality check needs to be performed when the ordinary production line is under maintenance which is expensive. The supplier of installation products possesses more complex recondition process. The reuse hub performs recondition from the customer's desire. If they want another color on a product, they repaint it at the reuse hub. However, they do not have the knowledge on all materials and contact suppliers for support if needed. Even though the process of recondition could be expensive and complex, there is a desire from the market that the suppliers should do it since they are best at it. In line with the industrial network approach, actors rely on each other's unique resources and capabilities. Suppliers possess the knowledge and capability to recondition materials, since they produce it from the beginning. Other actors in the industry depend on suppliers to perform the recondition properly. Furthermore, suppliers have informal power of the recondition due to the knowledge ownership of the materials. Since the market prefers suppliers to perform recondition, it indicates that trust and power align. It is important to have in mind that only because the suppliers have production systems in place, it does not mean they are already adapted to the reused materials. It is still essential to change the production lines to also fit the reused materials, which is a costly procedure. However, because of long-term trust and accumulated expertise, the suppliers are still expected to perform this role, and most appropriate for it.

5.3.7 Storing

After reconditioning, the material should be stored. Regarding the projects, the property owners manage the storing themselves. This is not considered their core business, but something new they have implemented to facilitate their work with reused materials, and because there are no other options. Some property owners utilize the reuse hub for the materials they will not reuse. The material is then stored at the reuse hub until another property owner purchases the material. From the processes of suppliers, they store the material once reconditioned. Analyzing the storage possibilities, one challenge is that the reused material contributes to increased tied up capital, since the suppliers do not know when the material is demanded. Since there is a desire that the processes of reused materials should work similar to the newly produced processes, one suggestion is to store the reused material together with the newly produced. However, it is of highest importance to keep them separated for customers to choose whether they desire reused or newly produced. Regarding this, traceability becomes a concern. Today, it is difficult when dismantling a property to know where the material is originally from. The whole industry needs improvement in gathering data about what material is installed in the property, to facilitate the traceability of the materials when being reused. Furthermore, the industry argues the quality of reused material as the same as newly produced. It should therefore not depend what material is used in the property. However, the contract of construction projects states how much of the property should contain reused material, implying the importance of knowing what material is reused and what is newly produced.

5.3.8 Contracting for the reuse of materials in new projects

When a property owner initiates a construction project focusing on reused material, the number of reused materials required in the property is stated in the contract. There is, as mentioned earlier, a desire from the industry to be able to order reused material similarly to newly produced material. Therefore, one activity for the supplier is to rearrange their websites appropriate for reused materials. The wholesaler of steel manages this today, where the customer can choose to purchase reused or newly produced material. This should be possible for other suppliers to manage. It will also facilitate the ratio of reused and newly produced materials. If one property owner needs 100% of one material, it can order what percentage exists of reused materials, and then the rest as newly produced, within the same order. Some representatives state the importance from the property owner to know numbers on the reduced impact of the environment when purchasing reused materials instead of newly produced. The suppliers therefore have the responsibility to conduct data on the effects when purchasing reused materials instead of newly produced.

As mentioned in 5.3.4 Transportation, there might be an actor between the construction site and the supplier that manages the material. If so, it is important with collaboration and communication between that actor and the supplier. If the property owner orders material through a wholesaler, and not directly by the supplier, it should work the same for reused material since there is a demand from the market to be able to order reused material and newly produced at the same time.

One concern regarding the differences between reused and newly produced material is the warranty. The opinions differ among the industry whether the warranty is important or not. Some says that warranty becomes a challenge regarding reused materials. Some actors cannot provide product warranty at reused materials since they have not produced it from the beginning. From the interviews, one finding is a knowledge gap from the suppliers of what the customers desire. Talking to the property owners, the product warranty is a non-issue, because it is almost never utilized for newly produced materials. It is important to assure the material function when installed, but product warranty is seen as unnecessary. This emphasizes the importance of communication between suppliers and property owners, to find what is demanded from the market. It is important that in phase one of the collaboration tool create a vision stating what is truly valuable to stakeholders early in the process. It is important from suppliers to understand the market requirements, instead of performing the same procedures as before. The suggestion is therefore to look through the warranty of reused materials, where installation warranty becomes more essential than product warranty.

5.4 Summary and key insights

Chapter 5 analyzes the empirical data by connecting it to the theoretical frameworks, focusing on the construction industry's involvement in reusing materials and its alignment with the Industrial Network Approach, ARA model. The findings presented in Chapter 5 provide valuable insights into the actors, resources, and activities involved in the reuse process, as well as the current challenges faced in the market.

The analysis emphasizes property owners as the central figures in driving the reuse of materials, with their role as customers and decision-makers setting the foundation for the entire process. They are responsible for developing sustainable goals and deciding the proper disposal process of a facility or building, thus enabling a circular flow of materials. Construction companies possess a critical role in incorporating reused materials into the construction process. They manage the practical aspects of using these materials, including procurement and installation. Furthermore, the analysis identifies demolition firms as key actors, especially in projects where careful dismantling of materials is required. Without their efforts, many materials would not be able to be reused. Additionally, the coordination role brings expertise and ensuring smooth project execution. The coordination role is often filled by actors such as reuse hubs, consultants and architecture firms. The role plays a pivotal part in the beginning of the market's development due to the lack of reuse expertise. In the supply chain for logistics there is currently a gap, with no single actor taking on the responsibility for transportation and storage of reused materials. This inefficiency creates challenges in the reuse process, highlighting the need for a more centralized or coordinated logistics solution.

Property owners control critical resources, such as the ownership of the materials and the contractual agreements that determine if materials will be reused or not. Their decisions at the project's beginning directly influence the material flow. Logistics continue to be a challenging resource in the reuse market, with the lack of standardized processes for dismantling, packing and transportation leading to inefficiencies. The analysis suggests that clear guidelines for dismantling and packing materials are necessary to streamline the process and avoid damage to reusable materials.

The activities involved in reusing materials in construction can be mapped to traditional construction processes, with additional steps specific to material reuse. Key activities identified include inventory checks, dismantling, transportation and storage, and reconditioning. Inventory checks are essential to determine the condition of materials and their suitability for reuse. The process is, however, inefficient, as multiple actors conduct similar checks separately. There is a need for clearer guidelines and for property owners to take responsibility for these checks, they can do it themselves or outsource it. But property owners control that activity and need to make sure only one thorough inventory check is conducted. Dismantling is a critical activity which enables the materials to enter a circular flow. The involvement of demolition

firms is essential, but standardized dismantling instruction and packaging materials are necessary to improve the process. Transportation and storage of reused materials bring logistical challenges. Different scenarios for transportation, such as using third-party logistics or a central terminal, are brought forward. Effective communication and collaboration among the actors in the supply chain are the key to managing transportation and reducing inefficiencies. Reconditioning is an essential step before reused materials can be incorporated into new construction projects. Suppliers possess the expertise to recondition materials but face challenges in adapting production lines to handle reused materials cost-effectively. The market's preference for suppliers to perform reconditioning is evident, given their deep knowledge of the materials.

Sustainability has become a key driver in the construction industry, market requirements are increasingly pushing for the incorporation of reused materials into processes. Property owners are placing greater pressure on construction companies and suppliers to meet environmental goals, making collaboration and communication among all actors crucial. Actors in the market must collaborate and coordinate effectively to make sure the reuse process works as smoothly as possible especially as demand for reused materials is growing. The industry also needs to address the challenges posed by costs associated with reusing materials, including dismantling, storage, and reconditioning. While reused materials can be cost-effective in the long term, the upfront costs remain a significant challenge. Collaborative efforts between property owners and suppliers to share the financial burden are necessary to create a more viable market for reused materials.

All identified actors, resources and activities are presented in Figure 18.

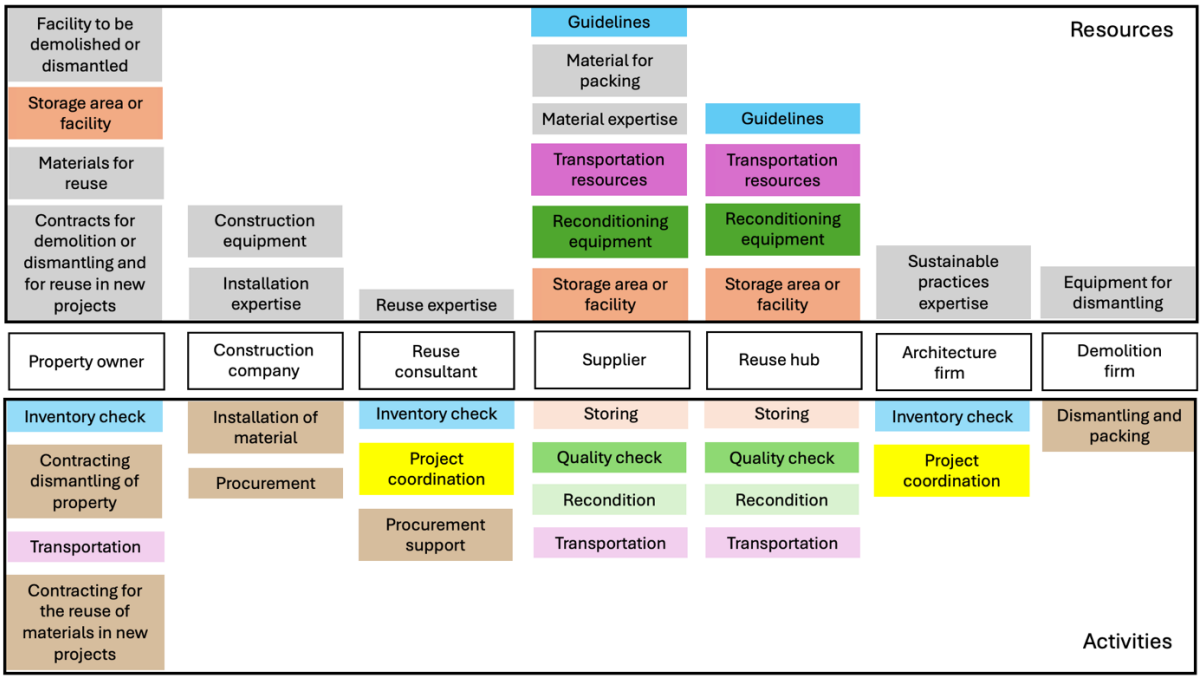

Figure 18: The identified actors are in the boxes with black frame. Above them, the identified resources are presented, and below the boxes with black frame the activities. The grey and beige boxes are connected to only one actor, while the other colored boxes are connected to more than one actor. The tinted colored boxes are activities connected to the resources in the same color.

6. Discussion

This chapter answers research question two and three. The first subchapter explains the key factors influencing the whole reuse market, and also more specific how the factors influence the suppliers. The second subchapter argue for the supplier's role in the market of reused materials. This is conducted by providing four main processes the supplier needs to manage in order to scale up the market of reused materials.

6.1 Key factors influencing reuse market

The adaptation of reused materials in construction projects is driven by several interconnect factors, with the main driver being environmental sustainability. The projects in the report, were all initiated by property owners with the aim to lower their environmental footprint. The primary driver in this regard is environmental sustainability, in alignment with the global climate goals set by the Paris Agreement. These goals have had a significant impact on the construction industry, encouraging property owners to seek ways to minimize their carbon emissions. Boverket stated that Sweden has their own climate goals based on the Paris Agreement, one being that 70% of all materials in the construction industry should be reused or recycled (Boverket, 2024). This aligns with the empirical data where representatives stated that they needed to manage their disposal processes differently. Reusing materials is, based on the interviews, seen as an effective way to achieve this, as it reduces the demand for virgin material, thereby lowering the environmental impact of new construction.

In the same way as the environmental benefits, the question of whether reusing materials can also lower construction costs has become of consideration. While the cost regarding handling, dismantling, and transporting reused materials can add complexity to the equation. If the processes regarding the recovery of material are iterated, there is a possibility that these may be streamlined and thereby reduced cost-wise. There is a need for the costs to be reduced for the profitability of the reused materials market. By addressing the potential of streamlining the recovery processes there is a possibility to lower the costs, especially if the market of reused materials were to expand. The financial aspect of working with reused materials remains a significant factor affecting the supply chain role of suppliers. While the cost of the reused material itself may be competitive with new materials, the added costs of dismantling, storing, reconditioning, and transporting the materials often make the reuse process more expensive than using new materials. This problem of additional costs becomes evident in the empirical data, where representatives from property owners and suppliers noted that reusing materials results in higher costs, specifically in the early stages of material recovery and reconditioning.

The weight of cost is not only shared by property owners but also suppliers who must invest in the necessary development of their flows and processes to handle reused materials. Some

suppliers have highlighted that the financial risks involved with sourcing, reconditioning, and reselling reused materials make the market less attractive unless additional financial incentives or support are provided. Property owners have raised concerns about the added costs of reusing materials, ranging from transportation and storage to quality assurance. The problems concerning the reuse process make it unfeasible, especially regarding large-scale projects.

Leising et al. (2017) states that there is need for an inclusive vision with collective processes. While a vision from the property owners has been present in the projects, it should be adapted as a part of their regular practices. Creating collective processes in their regular practices, specifically for reused materials, could facilitate alignment in the supply chain for all actors involved. This argumentation is also strengthened by the Industrial Network Approach. Axelsson and Easton (2016) consider that a collaborative context in the network increases the likelihood of working together and adaptation to change. Therefore, suppliers and property owners should work together to find ways to share the financial burden associated with reused materials processes. Potentially sharing investments in storage facilities or streamlining processes for dismantling and reconditioning materials. Moreover, financial models that allow property owners and suppliers to split the costs of reusing materials could make the market more financially viable.

As more property owners focus on sustainability, they're starting to require the same of everyone in the construction supply chain. This means other actors in the supply chain are receiving increasing pressure to work with reused materials. To facilitate this the property owners should create a circular vision including multiple stakeholders, in line with the collaboration tool's first step (Leising et al., 2017). With sustainability becoming such a big priority in construction, there is no alternative than acknowledging the fact that the demand for reused materials is growing. Projects Y and Z are great examples of this trend in action. These projects are testing out how to reuse large amounts of materials on a bigger scale, using digital tools to make the process smoother. The goal is not just to lower their environmental impact, but also to meet the rising demand for greener practices in the industry. Property owners are actively seeking ways to lower emissions and meet sustainability targets, and this shift is encouraging everyone involved in construction to find and incorporate reused materials in their practices.

However, it is not solely about sustainable practices, there is also a market opportunity. Construction companies involved in these projects have needed to adapt their practices to incorporate reused materials in the construction. As property owners require more reused materials in their properties, it appears that the industry is moving toward more sustainable practices. Therefore, there is an opportunity for actors to develop their operations, making them suitable for the demands from customers, thus, strengthening their position in the industry. This is also a shift where clients and tenants are prioritizing environmentally friendly buildings.

Effective communication and collaboration are something that have been the strengths of the projects. As stated by Leising (2017) and Dewagoda (2022) it is important to focus on value added activities throughout the total life cycle. Therefore, stakeholders could evaluate the possibility of using non-traditional contracts to ensure the involvement of the whole supply chain. When all the actors have been invested in the projects, communication and collaboration have been facilitated. Therefore, it is of great importance that the reused material practices focus on making the processes based on a collaborative approach where all the actors are invested in ensuring successful practices for reused materials. The already complex nature of the construction industry becomes more complicated when including reused materials in the processes. Multiple stakeholders are involved in sourcing, processing, and distributing materials which require transparent communication and collaborative relationships. Therefore, effective communication and collaboration can be seen as an enabler to overcome the challenges within the supply chain for reused materials.

The ARA model highlights the importance of resource and activity exchange between actors in a network (Axelsson & Easton, 2016). For suppliers, this indicates collaborating with demolition firms, property owners, construction companies and other stakeholders to ensure a steady flow of reusable materials. Without strong communication, the reuse process is fragile, which can result in delays, inefficiencies, and missed opportunities for a process that is already cost-sensitive.

In several of the projects, property owners were in direct communication with suppliers about the need for reused materials, but this communication became increasingly difficult as projects scaled. Property owners and the ones responsible for sourcing the material were concerned with the time-consuming nature of searching for reused materials which made the process unfeasible for other projects. The need for an intermediary or more structured collaboration became apparent suggesting that there is a need for a more collaborative and communicative approach to scale up the reused materials market. Both Dewagoda et al. (2022) and Leising et al. (2017) emphasized the need for collaborative development of circular processes and consequently assess and improve the processes. Collaborative processes would facilitate the development of the market of reused materials. After structuring the collaborative processes, the actors in the supply chain could benefit from assessing and improving the processes to make it more competitive with the traditional linear market.

Logistics is also included in collaboration, for reused materials to flow efficiently from one actor to another, there must be a shared understanding of how to handle, store, and transport the materials. This requires coordination between demolition firms, suppliers, construction companies and other stakeholders in the supply chain to ensure that materials are not only taken back but also reused. Leising et al. (2017) consider that stakeholders should be prepared to step outside of their normal responsibilities and be flexible to make sure that all necessary processes are performed. Aside from taking back the material, it also needs proper storage, processing,

and deliver to end users in a timely and cost-effective manner. In some of the reused material processes, suppliers are already claiming an active role in managing logistics, but this is not a standard practice across the industry.

Another challenge the suppliers face in the reused materials market is matching demand with supply. The empirical data highlights the difficulty of sourcing sufficient quantities of reusable materials. This aligns with what Leising et al. (2017) highlights regarding circular vision, more precisely the lack of a circular vision in the market. The problem of supply scarcity becomes apparent when suppliers cannot secure the right materials in the right quantities to meet demand. One possible reason for the scarce supply of reused materials could be that organizations that are incorporating reused materials in their practices today are currently working in line with scenarios one, two and three from the AFRY report (Bosch et al., 2023). For instance, property owners may want to reuse materials such as doors or ceiling tiles, but the available stock at the moment may not align with their needs. This mismatch between supply and demand often results in materials being discarded or stored within another organization instead of reused in the market.

However, some suppliers are currently developing their reused processes, but they are not spreading the information that they are reclaiming materials or products. The representatives raised concerns about receiving more materials than they currently can handle. Therefore, there is a great need for suppliers to develop their capacity so that they can manage greater volumes. From the empirics, a lot of representatives claimed that it is problematic with both the selling process of reused materials as well as the process of reclaiming sufficient volumes. This is further complicated by the need for high-quality materials that meet specific standards which can make procuring sufficient volumes of functioning reused materials complex.

To handle these mismatches, suppliers should focus on close collaboration with demolition firms, property owners as well as the actors responsible for material procurement in construction projects. The establishment of an actor that could function as a middleman handling the coordination and or the logistics for the reclaiming of materials to be reused. This actor could act as intermediaries between the stakeholders in the reused materials market, ensuring that materials are sourced and delivered more efficiently. In order for the reused materials market to be upscaled it is important that actors start collaborating outside of their organization boundaries and focus on develop their reuse processes in accordance with scenario four from the AFRY report (Bosch et al., 2023).

6.2 Suppliers' role in the market of reused materials

Several property owners state the process of finding demand to the potential reused materials as challenging. Furthermore, there is also a challenge to find the reused material they need when constructing a property. To facilitate this, the suppliers possess an important role. To both take

back and offer reused material will contribute to a matching supply and demand, without other actors in need of searching for reused materials and where to transport the reused material. Dewagoda et al (2022) emphasize circular value proposition as important when transforming to a circular construction industry, where take-back concepts are facilitators. The empirical data argues suppliers to take that role in the construction industry, implying connections between the theory and the empirical data.

From the analysis, there are four main processes covering all steps for a supplier working with reused materials. These are adapting operations to enable circular flows, take back process, process at the supplier, and selling reused material. They are presented in Figure 19. The process can be seen as circular since there will always be need for adjustments in the preparation phase to adapt to the increasing reused market.

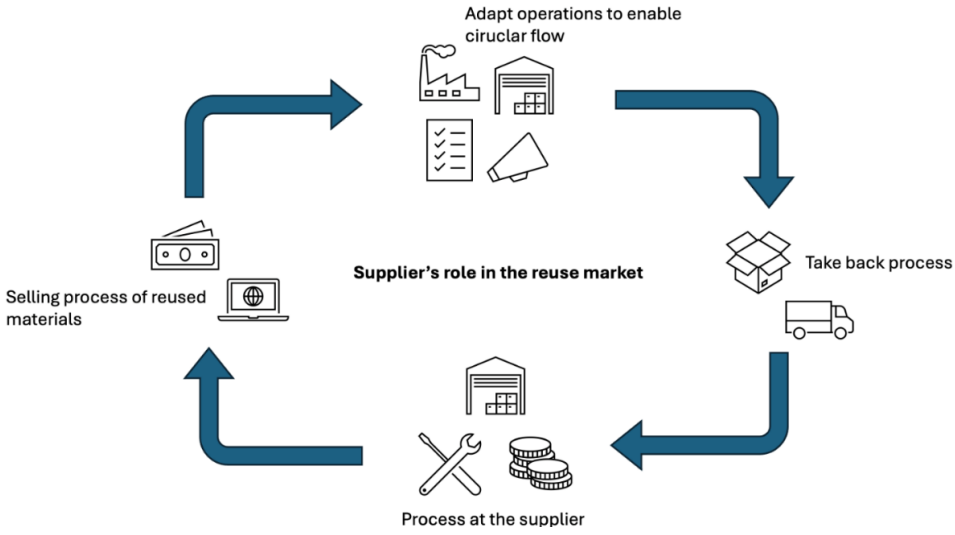

Figure 19: Supplier's role in the reuse market

6.2.1 Adapt operations to enable circular flow

This is the preparation step for a supplier, to adapt the operations to enable the managing of reused materials. According to Dewagoda et al (2022) apprehension is one of five concepts essential as a foundation towards circularity. Apprehension implies the importance of knowledge to successfully implement circular practices, for instance reused materials. The preparation step contributes with increased knowledge and expertise within the suppliers to work with reused materials and therefore aligns with the theoretical framework. The production requires expansion to manage recondition of reused materials. Depending on material and the condition of the material as it arrives to the supplier, different reconditions is required. The supplier of their material possesses the most knowledge about their material and therefore knows how to best recondition it. This goes in line with the industrial network approach where actors in the industry rely on other actors' expertise and unique resources (Axelsson & Easton,

2016). The actors in the construction industry rely on suppliers' knowledge about their material and therefore desire them to manage the recondition of the material. The storing area also needs expansion. However, it is difficult to know how much the storing area needs to expand, but for the market to scale up, it is important for the suppliers to create opportunities to store the reused material. If wholesalers are included in the process of reusing materials, there is a need for coordination between the wholesaler and supplier to decide the respective storage area.

Furthermore, guidelines for inventory check and dismantling and packing needs to be created. These are standardized guidelines that should be available on the website of the supplier, to facilitate the access to them. The guidelines for inventory check should include information on how the material should look like to be approved as reused. The guidelines for dismantling and packing should clearly explain the procedure, and how to pack them best to minimize the risk of damaging the material during transportation. Leising et al (2017) emphasize the importance of not only focusing on economic benefits for one actor, but also environmental and social value to the construction project. The guidelines are an example of the two last values, since it facilitates the reuse of materials. This implies environmental value since the need for newly produced materials is minimized, and social value since it enables smoother processes when dismantling the material for the actor performing it.

The last important part of the preparation step is for the supplier to promote the work of reuse. It is important to inform the construction industry that they offer take back solutions of their material. Their website is an essential channel to reach out to the property owners, but also to include themselves in networks focusing on the transformation of the reuse market. The industry needs to be aware of the options of reusing materials.

6.2.2 Take back process

Once the processes of the supplier are adapted to enable reused materials, the next step is the physical take back process. The inventory check is managed by the property owner, and the guideline from the supplier enables smooth and fast inventory check. The supplier should provide packing material to facilitate the packing and transportation of the dismantled material. Communication and collaboration between the property owner and the supplier is important to plan the deliveries of the packing material. This is connected to phase two in the collaboration tool created by Leising et al (2017). According to them new collaborations are created in phase two, focusing on value added activities for the whole industry. It is important with proper collaboration between the property owner and the supplier to facilitate the process of packing material. This creates new ways of collaboration between actors in the construction industry. The property owner pays a deposit for the packing material, which is then paid back once the packing material is returned to the supplier. The material is then transported to the supplier, through one of the suggestions presented in 5.3.4 Transportation.

6.2.3 Process at the supplier

This step includes quality check whether recondition is needed or not, recondition and reimbursement, and storage. When the material has arrived at the supplier, the condition of it needs to be assessed. Within this step, the suggestion is to decide the value of the material, to reimburse the property owner for contributing to reused materials. Regarding what type of recondition the material demands, the suggestion is to create three price categories. The first one is if the material can be reused directly, without recondition. The reimbursement to the property owner is in that case high. The next price category is if recondition is required. The reimbursement is then set to medium. In worst case, the material cannot be reused at all and needs to be recycled instead. In that case, the reimbursement is low. The different price categories are presented in Table 6.1. Once the reimbursement for the material is decided, that together with the deposit of packing material is paid to the property owner. The reimbursement is seen as a compensation for the extra time and resources the property owner must pay when the demolition firm dismantle the property instead of demolition it. It is also an economic incitement for the property owner to choose to reuse the material instead of recycling or dispose as waste. This goes in line with Yang et al (2022) previous research where the initiatives must be based on collaborative financial investments, instead of each actor aiming towards the highest margin possible for its own activities. The reimbursement represents the suppliers desire of creating collaborative winning in the industry instead of only focusing on the economic incitement for themselves. The supplier then stores the reused material together with the newly produced. Similarly to the preparation phase, the storage area depends on the interaction with other actors when taking care of the material. It is up to the supplier to collaborate with the other actor, for instance a wholesaler, to decide the storage possibilities.

Regarding the challenge of traceability of the material, coordinated systems are required to improve the traceability of the material. In line with phase three in the collaboration tool from Leising et al (2017), design of collaborative processes becomes essential. The storage issue and traceability gap require collaborative process design between actors in the industry. It is not only about managing physical space but agreeing on data standards and shared systems for storing and accessing information. Furthermore, Dewagoda et al (2022) emphasize proper information management as important when moving towards circular construction industry. Increased traceability and transparency among actors regarding the material facilitates the process of reused materials. Suppliers have an important role in facilitating this. One suggestion is therefore for suppliers to use material passport, including information about the material history. After reconditioning, when storing the material, information about where the material is from, and other important data start the process of facilitating traceability during the lifecycle of a construction project.

Table 6.1: The three different price categories when assessing the condition of the material.

Condition	Reimbursement
Reusable directly	High
Recondition required	Medium
Recondition not possible → Recycling	Low

6.2.4 Selling process of reused materials

The last step implies selling reused materials to the construction projects. The market requires the reused materials to not be more expensive than newly produced materials. However, the suppliers must make some profit on the reused materials to make it worthy for them. The costs the supplier must pay for the reused material is the reimbursement to the property owner, reconditioning, storage and the additional transports for gathering the material. These costs are suggested to be translated to a price, which cannot exceed the price of new material. This challenge highlights the need for alignment among actors in the supply chain. According to Leising et al (2017), transitioning to a circular construction industry involves shifting from isolated economic optimization to collaborative value creation. The pricing model must reflect a shared economic logic, where profits are not maximized individually but balanced collectively to support the viability of reuse.

Beside determining the price of the reused material, the suppliers must adopt their websites and other selling channels to suit reused materials. As mentioned in 5.3.8 Ordering material, the desire is for the procedure to order reused material to be the same as newly produced. Therefore, it is recommended to arrange the websites to facilitate the purchase of reused materials. Furthermore, it is recommended to visualize the difference in environmental impact when purchasing reused material instead of newly produced. It is therefore recommended for suppliers to implement data on the environmental impact on their websites. Rearranging the websites to include reused materials and the environmental impact of them extends the theoretical framework of actor learning described by Leising et al (2017). While the original framework discusses the higher-order learning as a transformation of actors' goals and values, the recommendation adds a concrete mechanism, impact visualization, that supports this learning. By facilitating the process of purchasing reused materials and making environmental data transparent and accessible at the point of sale, suppliers can influence purchasing behaviors

and shift customer perception of value from only economic to also include environmental considerations.

6.3 Chapter summary

The primary driver for adopting reused materials in construction is environmental sustainability. Since the global climate goals from the Paris Agreement, property owners have become increasingly inclined to reduce their carbon footprints. Reusing materials reduces demand for virgin materials and lowers construction emissions, supporting sustainability targets. While the environmental benefits are clear, cost efficiency also plays a role. Initially reusing materials can increase costs due to dismantling, storage and transportation. However, if the processes are streamlined and the reuse market is developed there are potential savings in the construction industry. As property owners need to lower their carbon emissions they create market requirements that stakeholders incorporate reused materials in their processes. In order to meet these market requirements and property owners reach their sustainability goals, collaboration and communication among the supply chain actors become critical. Since the reuse process involves multiple stakeholders, transparent communication is needed. There is also a need for efficient coordination of material flow, including dismantling, storage, and transportation, to mitigate logistical challenges. Furthermore, matching supply with demand is the last of the highlighted challenges. Many suppliers struggle to source sufficient quantities of reusable materials, leading to mismatches resulting in materials being disposed of or stored unnecessarily. Better coordination between among the stakeholder to align supply with the industry's demand.

Suppliers possess a critical role in scaling developing the reuse market, responsible for four key processes. Suppliers need to adjust their operations to handle reused materials, including developing production capacity for reconditioning and increasing storage. Furthermore, clear guidelines for inventory checks, dismantling and packing should be provided to streamline the process. Suppliers must establish a take-back process for materials, including providing packing materials and coordinating with property owners for a smooth material flow from dismantling site to the supplier's location. When materials are received, suppliers need to perform quality check and recondition them as needed. A reimbursement model for property owners should be introduced based on material condition. Reused materials should be priced, taking reconditioning, storage and transportation costs into consideration. Suppliers should update sales channels to facilitate easy ordering accompanied by new materials and highlight the environmental benefits of reused options. By addressing these processes, suppliers can improve efficiency and contribute to developing the market for reused materials.

7. Conclusion

The research was conducted with the purpose of identifying and analyzing the supply chain role of suppliers in the market of reused construction materials. Three research questions were created contributing to the purpose of the research. Answers on these are presented in the first subchapter. The second subchapter provides limitations and the last future research possibilities.

7.1 Answering the research questions

RQ1: What current actors, resources and activities are identified in the market of reused construction materials?

From the analysis, seven actors were identified. Furthermore, activities controlled by these actors and resources exchanged between them were identified. Storage area or facility, transportation resources, reconditioning equipment and guidelines exist within several actors. Inventory check, transportation, recondition, storing, quality check and project coordination are activities controlled by several actors. All identified actors, resources and activities are presented in chapter 5.4 Summary and Key Insights.

RQ2: What key factors affect the supply chain role of suppliers in the market of reused construction materials?

Different key factors were identified, the key factors are affecting what the suppliers should do and what role they should incorporate. The key factors identified were costs regarding handling, dismantling and transportation. Furthermore, currently there is a mismatch between supply and demand at the same time as the offering of reused materials has become a market requirement. As suppliers are heavily involved in the flows logistics also affect how suppliers should approach the reused materials market. In the report it was found that in order to have a successful reuse process there is a need for collaboration and good communication between the actors. Lastly, the current procurement process of reused materials is inefficient and the way suppliers offer their reused materials becomes of importance.

RQ3: What activities should suppliers be responsible for in their supply chain role regarding the development of the reused construction materials market?

Four main activities are identified as crucial for suppliers to be responsible for within the development of the reused construction materials market. Each main activity consists of smaller activities connected to the main ones. The first main activity is to adapt operations to enable circular flow. Included in this activity is rearranging the production for recondition, increase storage possibilities, creation of guidelines for inventory check and dismantling of material, and

finally to promote their work of reused materials. The second activity is the take back process, where providing packing material and transportation is included. The third activity implies the process at the supplier and includes quality check whether recondition is needed or not, recondition and reimbursement, and storage. The last main activity is the selling process of reused material. Within this activity, suppliers need to set a reasonable price for the reused material and update their websites and other selling channels to promote their work with reused materials.

7.2 Limitations

There are limitations to consider when interpreting the findings of this research. First, not all construction materials available on the market were analyzed, which may have led to gaps in understanding or overlooked insights. The exclusion of certain materials may limit the comprehensiveness of the conclusions. Secondly, while the key actors were interviewed in the study to provide expert perspectives, the study did not capture the views of all stakeholders involved. Finally, the reuse market remains highly dynamic and is still evolving. Therefore, the findings may quickly become outdated. Changes in market conditions, policies or practices could affect the relevance or accuracy of the data collected.

7.3 Future research possibilities

This research firstly contributes with a brief identification of the actors, resources and activities in the market of reused construction materials. Other than that, the research is focused on the suppliers' role when it comes to the market of reused construction materials. One future research possibility is therefore to analyze the role of other actors in the market of reused construction materials. There are many actors involved in the work with reused materials, and to be able to scale up the market there is need for analyzing the role of all actors in the construction industry.

Another future research possibility is to investigate the economic incentives and business models that can support a viable reuse market. Understanding how financial structures, policy instruments, and circular economy principles can be combined to create profitable reuse strategies is essential. Future research could explore which pricing models and collaboration between actors can stimulate demand and reduce risk.

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Appendix

Appendix A – Interview questions

1. Explain about the company and your role at the company
2. What is the driving force when working with reused materials?
3. How do you work with reused materials today?
4. How would you explain the demand of reused materials today?
5. What actors do you collaborate with regarding reused materials?
6. What is your experience in collaborating with a supplier in a reuse project?
7. How does the work change when handling reused material instead of newly produced?
8. What are the biggest challenges when working with reused materials?
9. How does the business model change when working with reused materials compared to newly produced?
10. What are the logistics differences when working with reused material?
11. What should suppliers do to contribute to a scale up of the reuse market?
12. What do you think about the future of reused materials in the construction industry?

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