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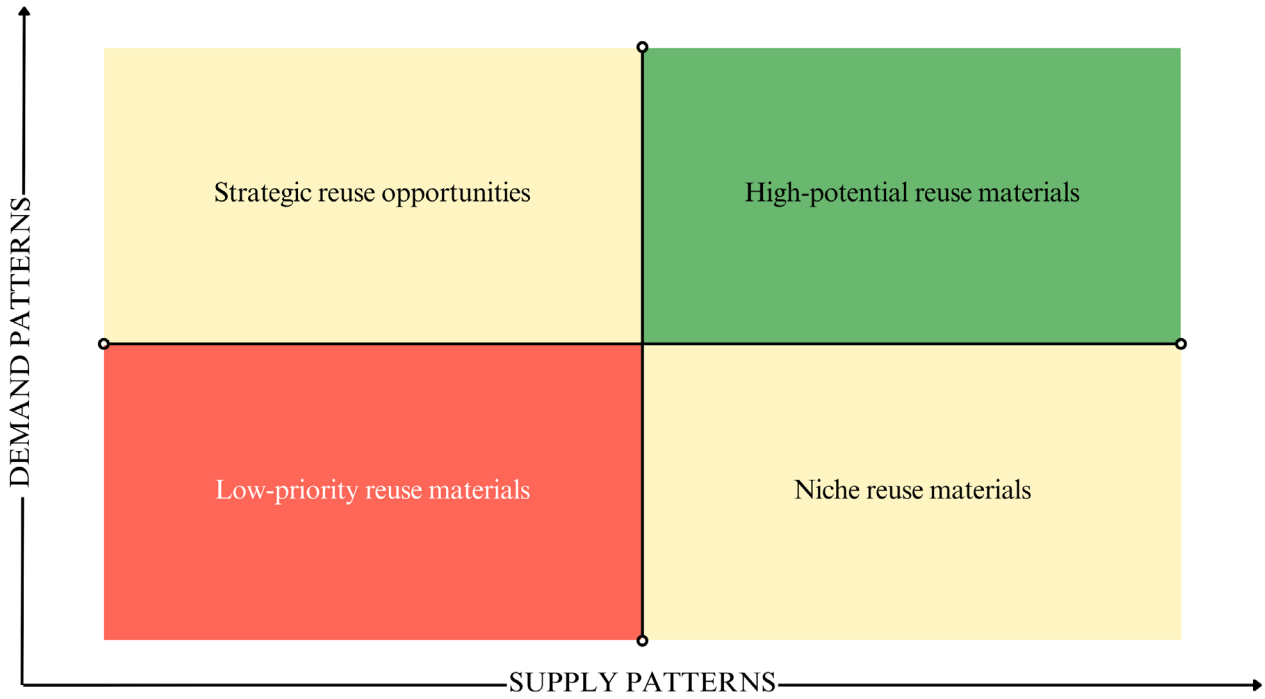

Assessing Material Reuse: A Framework for Practicality and Financial Feasibility from Suppliers' Perspective

Master's Thesis in the Master's Programme Design and Construction Project Management

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CHALMERS UNIVERSITY OF TECHNOLOGY
Gothenburg, Sweden 2025
www.chalmers.se

MASTER'S THESIS ACEX30

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Cover: Graphic result of the framework for assessing practicality of reused materials based on their supply and demand patterns.
Department of Architecture and Civil Engineering
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ABSTRACT

The construction sector is today a large contributor to the environmental impact in Sweden and the world. It is evident that the industry is facing structural changes over the coming years to minimize the environmental impact. Reusing materials and components have been on the uprise as one of the solutions to this problem and have gained attention the last years. The research in the area is immature, especially regarding information about the suppliers of materials. Therefore, this study aims at researching what materials are the most practical and profitable to reuse from a supplier's perspective. First, the definition and concept of reuse have been investigated thoroughly since the vocabulary used today is often vague and differs depending on the situation and organisation. To further analyse different materials and their reuse potential a framework was developed based on a literature study to account for the most important supply and demand aspects as well as the financial aspects that affect the process of using different materials as reused. Some key areas were identified in the framework such as, environmental impact, logistical aspects and procurement of materials. To develop a result, 14 interviews was conducted divided between different types of actors in the industry. These interviews was the foundation of the results and were complemented by quantitative and informal data to provide a more comprehensive result. The study was able to develop a graphic system for evaluating different materials and therefore grade these materials based on their practicality and profitability in the area of reuse. The conclusion is that there are many materials suitable for reuse such as, paving materials, temporary materials, saved materials, furnishing and trim, but also materials that should be avoided, for example boards and insulation. In addition to this, several drivers for reuse were identified and included topics such as who the client is, the importance of definitions, and the market position of the supplier. The study shows that it is evident that reuse is something that everyone in the construction industry is going to be involved with. It is also a certainty that the suppliers in the construction industry are necessary to develop a functioning reuse system and that they should get involved rather sooner than later.

Key words: Reuse, Circularity, Material Suppliers, Practicality, Profitability

Utvärdering av Materialåterbruk: En Modell för Praktisk och Ekonomisk Genomförbarhet från Leverantörernas Perspektiv

Examensarbete inom masterprogrammet Organisering och Ledning i Bygg- och Fastighetssektorn

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SAMMANFATTNING

Byggsektorn är idag en stor orsak till den miljöpåverkan som sker både i Sverige och globalt. Det är tydligt att branschen står inför strukturella förändringar de kommande åren för att minska sin miljöpåverkan. Återbruk av material och komponenter har vuxit fram som en av lösningarna på detta problem och har fått ökad uppmärksamhet under de senaste åren. Forskningen inom området är dock fortfarande omogen, särskilt vad gäller information om leverantörer av material. Denna studie syftar därför till att undersöka vilka material som är mest praktiska och lönsamma att återbruka ur ett leverantörsperspektiv. Först har definitionen och begreppet återbruk undersökts noggrant, eftersom det språkbruk som används idag ofta är vagt och varierar beroende på situation och organisation. För att vidare analysera olika material och deras återbrukspotential utvecklades ett ramverk baserat på en litteraturstudie, där de viktigaste praktiska aspekterna av tillgång och efterfrågan samt ekonomiska faktorer som påverkar processen att använda material som återbrukade presenterades. Några nyckelområden som identifierades i ramverket var miljöpåverkan, logistiska aspekter och materialanskaffning. För att nå ett resultat genomfördes 14 intervjuer med olika typer av aktörer i branschen. Dessa intervjuer låg till grund för resultatet och kompletterades med kvantitativa och informella data för att ge ett mer heltäckande resultat. Studien har tagit fram ett grafiskt system för att utvärdera olika material och därmed gradera dem utifrån deras praktiska användbarhet och lönsamhet inom återbruk. Slutsatsen är att det finns många material som är lämpliga för återbruk, exempelvis markbeläggningsmaterial, tillfälliga material, räddat material, samt inredning och ytskikt men också material som bör undvikas, såsom skivmaterial och isolering. Utöver detta identifierades flera drivkrafter för återbruk, såsom vem beställaren är, betydelsen av tydliga definitioner, samt leverantörens marknadsposition. Studien visar tydligt att återbruk är något som alla i byggbranschen kommer att behöva förhålla sig till. Det är också uppenbart att leverantörerna i byggindustrin är avgörande för att utveckla en fungerande återbruksprocess och att de bör involvera sig förr snarare än senare.

Nyckelord: Återbruk, Cirkularitet, Materialleverantörer, Praktisk Genomförbarhet, Lönsamhet

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Acknowledgements

This master thesis has been the final step of our studies in civil engineering and our master's in Design and Construction Project Management at Chalmers University of technology. This thesis was conducted in spring 2025 in Gothenburg, Sweden.

This work has been made possible by everyone we have met throughout the period of the study. We would like to express a special thank you to our supervisors whose support and guidance have made this thesis possible. Thank you to Ahmet Anil Sezer at Chalmers University of Technology for your expertise in the field of circularity and reuse but also in the process of report writing where you have guided us through the academic jungle. Thanks for taking the time to meet us throughout the process whenever we have felt lost or confused. Without you the work would never have turned out this good.

A big thank you to Derome and our supervisors at the company. Niklas Holmberg and Linn Henegård, you brought us into the company and made us feel at home from the first day, throughout the work you have been a huge support. Your knowledge and contacts in the construction sector made this work possible. To always have someone to ask on a daily basis have been hugely valuable for us.

This work has largely depended on all the people that we have interviewed and visited. Your enthusiasm and commitment to help us have been overwhelming and we would like to express our utmost gratitude to every valuable insight and knowledge that you have provided.

Thank you to our opponents, Ludvig Åberg and Johan Näswall for your valuable insights and engagement in our project. At last, we would like to thank everyone involved in the work and throughout our studies for making this possible. We feel grateful to have been able to work with such an interesting subject as a last step of our studies.

Gothenburg, June 2025

Markus Forsberg

Wilma Stålarm

1 Introduction

As the world faces a growing climate crisis, new demands and innovations are essential for driving positive change. The construction and real estate industry plays a significant role in global emissions, accounting for 22 percent of Sweden's greenhouse gas emissions in 2022, according to Boverket (2025a). While this marks a 12 percent reduction compared to 2008, largely due to more energy-efficient buildings and improved supply chains, the sector still has a considerable environmental impact. Emissions from new construction represent 21 percent of the total, with the rest stemming from heating, maintenance, renovation, and reconstruction of existing buildings. To address these challenges, the Swedish government introduced a climate framework in 2017, aiming for net-zero greenhouse gas emissions by 2045 (Naturvårdsverket, 2024). As part of this initiative, the construction industry has developed a roadmap emphasizing circularity, recognizing that a significant portion of emissions from new construction originates from material production.

Beyond emissions, the construction and real estate sector is also responsible for 40 percent of Sweden’s total waste and 19 percent of its hazardous waste, including materials from infrastructure projects (Boverket, 2025a). Sweden's environmental goals state that by 2025, 70 percent of all non-hazardous construction waste should be prepared for reuse and recycling (Naturvårdsverket, 2023). Most of this waste such as excavated soil, concrete, bricks, clinkers, asphalt and dredging soil derives from infrastructure projects. However, structural timber, timber for castings and facade materials also constitute a significant portion of waste generated in construction (Naturvårdsverket, 2023). To address this issue, the EU Waste Hierarchy prioritizes waste prevention by designing and utilizing resources efficiently from the outset. Materials that cannot be prevented from becoming waste should first be prepared for reuse before recycling (European Union, 2024). Given that the construction industry generates the largest amount of waste in Sweden, it has a significant responsibility to transition towards more resource-efficient practices.

Reuse in construction has been gaining attention the recent years, but its implementation remains limited. The potential for incorporating reused materials is vast and is crucial to achieving environmental goals. The roadmap for net zero emissions in 2045, includes increasing the use of reused materials in new construction (Fossilfritt Sverige, 2024) showing the growing relevance of the topic. Reuse is also efficient to reach environmental certifications for new construction project, as carbon emissions from reused materials are substantially lower compared to newly manufactured materials. Several pilot projects in Sweden have successfully demonstrated how reused materials can help achieve sustainability targets. In Gothenburg, several large real estate companies have agreed to prioritize reused materials in renovation and new construction projects (Business Region Göteborg, 2025). By doing so, they will also

require reuse in tenders and contracts with designers, contractors, and suppliers, further promoting circular practices in the industry.

Currently, suppliers of reused materials primarily consist of local reuse hubs, which collect building components and materials from demolition projects, inspect and sort them, and resell them for use in other construction projects. However, these hubs face challenges in scaling up their business due to inconsistent material quality, limited knowledge, inadequate logistics solutions, and a lack of regulatory support, which makes it difficult for reused materials to compete with new materials (Van Uden et al., 2025) According to Van Uden et al. (2025) reuse hubs are expected to shrink in size, with suppliers and intermediaries taking over material handling while reuse hubs focus more on managing logistics. In Sweden, several office adaptation projects have utilized reuse hubs to source materials. Some real estate companies have created internal hubs to repurpose their own materials, while others have collaborated with external reuse hubs to secure reused materials for their projects. Despite their potential, reuse hubs continue to struggle with scaling their business and finding consistent customers for their products.

A key challenge in expanding the reuse of materials is understanding which materials are most profitable and practical from a supplier perspective. Without clear guidelines and economic incentives, suppliers may hesitate to invest in reuse due to uncertainties in quality assurance, demand fluctuations, and high handling costs. Therefore, conducting a study on the profitability and practicality of different reused materials is necessary to provide suppliers with a clearer framework for integrating reuse into their business models. Identifying which materials offer the highest economic and environmental benefits can support better decision-making, promote a circular economy, and help suppliers overcome logistical and financial barriers.

Existing suppliers of new construction materials have a competitive advantage in entering the reuse market due to their established infrastructure, logistics network and customer base. Their expertise in construction materials positions them well to integrate reused materials into their offerings. In contrast, reuse hubs face challenges such as inconsistent material quality and difficulty in building a steady customer base. Additionally, a lack of efficient logistics solutions and high handling costs have hindered suppliers from fully integrating reused materials into their operations. However, as demand for reused materials grows and clients increasingly require suppliers to incorporate them, there is a pressing need to explore how suppliers can integrate reused materials profitably and at scale.

1.1 Aim and purpose of the study

The aim of the thesis is to investigate how suppliers of construction materials can be integrated in the reuse market. This will be done by investigating what materials and components are suitable for reuse from a supplier perspective. Derome Bygg och Industri has been used as a reference company where some of the different materials analysed are applicable to their business. The materials will be evaluated based on their practicality and profitability for reuse. It will be investigated by answering the following questions.

- RQ1. What materials and components are most practical to reuse from a supplier's perspective?
- RQ2. What materials and components are most profitable to reuse from a supplier's perspective?

Several factors influence the practicality of reusing different construction materials, including logistics, legal regulations, and supply and demand. These aspects will be considered while finding the most practical materials to reuse. Different costs and the market share of materials will be studied to investigate what materials are most profitable. The aim is to provide valuable insights to construction material suppliers on which materials are best suited for reuse, thereby supporting the development of a more robust reuse market.

1.2 Limitations

The project will focus exclusively on activities related to construction materials and components within Sweden. It will not examine project-specific logistics, processes and marketing strategies. The study will be limited to reuse in buildings, excluding reuse in infrastructure projects. Not all building materials will be evaluated; the most common building materials will be studied as well as materials that have been reused in previous projects. The primary reuse model considered will involve materials being distributed through an external supplier. Reuse within individual projects will not be studied, as this process typically does not involve suppliers. The study will mainly focus on large construction projects such as residential buildings, offices and schools. It will not include single-family houses and minor construction projects. Furthermore, the study will be constrained by data availability and confidentiality restrictions, limiting access to detailed financial information.

2 Background

With an industry that are facing pressure to reduce its environmental impact, circularity have become a central concept in addressing this challenge. The concept is often vaguely defined and is mainly about retaining the value of materials and components for as long as possible through reuse, efficient resource management and circular business models. However, the implementation of circular strategies, particularly material reuse is limited in practice. In this chapter, the key aspects of circular construction and the supplier's role in an increased reuse market will be outlined. The definition of reuse and different forms of reuse will also be discussed to evaluate which materials are most viable to reuse, both practically and economically.

2.1 Circularity in construction

Circularity as a term is something that today is widely used for several objectives and areas and have different meanings and definitions depending on the situation. Circularity also exist on different levels and to different extent. Circular construction is defined as:

> "*Developing, using and reusing buildings, construction components or products and materials, areas, and infrastructure without unnecessarily depleting natural resources, polluting the living environment and affecting ecosystems*" (van Eijk, et al., 2021).

According to the report there are several aspects that are included in circularity for the construction sector such as Design for Deconstruction [DfD], material reuse and recycling, resource efficiency, circular business models, digitalisation and data management. Design for deconstruction is a term that have existed in the industry for several years and is a way to in the early stages of a construction project design and plan for the upcoming deconstruction and possible reuse of material and components (Fahlén et al., 2017). Materials reuse and recycling is something that is an important part when it comes to implementing circularity in the construction sector. However, the market today is still in its infancy and are not capable of dealing with circularity of major components or in major quantities (Boverket, 2024d). Resource efficiency is something that the construction has and continues to have issues with. Waste from the construction sector has increased over the last years while the number of materials recycled is about 55 percent (Boverket, 2025a). The possibility for the sector is endless when it comes to improving their material processes and by implementing reuse on a larger scale the sector could shift towards more circular business models.

2.2 Suppliers' role in a circular economy

Building materials is the foundation of the construction sector and without building materials the sector does not exist. Production of these building materials is also a big part of the total environmental impact of the construction sector. It is therefore evident that the suppliers of these building materials have huge opportunities to improve the sector and offer more circular concepts. The suppliers of building material possess a great deal of information that is often neglected during large parts of the building process. It is therefore valuable to involve the suppliers in the early stages of the design and planning phase of a project.

The report "*Vägen mot mer cirkulära byggmaterialflöden*" mentions five key aspects when it comes to the supplier's role in the circular economy and how they can improve their contribution to a more sustainable industry (Byggmaterialindustrierna, 2025):

1. Develop and manufacture resource-efficient materials and products that can be circulated and re-used.
2. Using recycled raw materials, waste and by-products to manufacture materials and products.
3. Upgrade embedded materials and products for increased functionality and longer lifetime.
4. Recovering materials and products for reuse, upgrading and remanufacturing.
5. Providing information and knowledge about materials and products.

The main roles relevant for this study is number 1 and 4 since those are relevant for working with reused materials. However, all these roles show the importance of the supplier in the transition towards a circular construction sector. In role 1, developing and designing materials and products that have a long lifespan while at the same time designing them for future dismantling is a key aspect for a circular supplier. In role 4, suppliers can reclaim products or materials that have reached the end of their lifespan. Here circular business models like leasing or selling a function rather than a product could be beneficial. After reclaiming these products or materials the supplier can resell them without any changes depending on the condition or they can be reconditioned and re-sold. The material could also be used in its entirety or in parts to form a new product or to be used as new raw material.

2.3 Dismantled materials

There is no set definition of what is classified as reuse. According to Miljöbalken chapter 15§2 (2025) "*reuse means the re-use of a non-waste product or component to fulfil the same function for which it was originally intended*". Materials that are classified as waste can also be reused according to Miljöbalken chapter 15§6 by "*inspecting, cleaning and repairing something that is classified as waste so it can be*

reused without further treatment". When dismantling materials from prior buildings it is important with careful dismantling to preserve their quality, a process that is more time-consuming than standard demolition. Once recovered, they can be utilized in renovation or new construction projects. These materials often remain functional for extended periods, making them well-suited for reuse. There are several companies specialized in deconstruction and demolition companies are gaining knowledge in deconstruction to facilitate reuse. There are several projects in Sweden where interior components such as windows, doors, ceiling tiles have been reused as well as façade materials and toilets and sinks. These materials are durable and have a long technical lifespan. Construction materials such as plasterboards, plywood, beams etc can also be reused although they require more complicated dismantling. The supply for reused products is large, counted to the number of buildings undergoing renovation and demolition in Sweden, but the processes are not set to put the materials in the market.

2.4 Reuse of excessive materials

Reuse in the construction sector do not have an exact definition and should therefore be dealt with cautiousness and transparency. There are some situations where there are room for interpretation when talking about reuse (Sveriges Kommuner och Regioner, 2023). The report states that if material being leftover and that normally would be considered as waste are reused in another project it could be considered as reuse. The environmental savings should not be considered and taken into the environmental calculation before the material is used in a new project. However, it is important that this does not cause the wrong mindset of creating more waste just to be able to reuse it later and gain environmental savings in another project. The same concept applies to over orders or wrong orders of materials; these are also to be seen as reuse with some requirements. Over ordered materials sent back to the supplier are not always to be seen as reuse if the material was not intended to become waste. Here a decision is needed for each project or overordered material. It is therefore important that the supplier is transparent of what they consider as reused materials and what their processes are.

Excessive orders or materials being leftover that are being reused in another project or setting that was first intended can therefore often be considered as reuse. Today there are a large quantity of excessive orders and materials being leftover on building sites. Since the waste from construction sites are not categorised to any major extent it is hard to know how much of this waste that are over ordered materials that are never used or if it is waste from the production. Estimates show that as much as 10-15 percent of all building material used on larger construction sites can be categorised as leftover materials that have not been used in the project (Industrifakta, 2025). In larger projects this can equal several tons of material that could be reused relatively quickly and easy with minimal handling and upcycling.

3 Theoretical framework

In the following part a theoretical framework has been created with the purpose of examining the research questions of what materials are the most practical and profitable to reuse. The literature has been used a basis for the framework to identify the main key points. This framework will later be the foundation on which the analysis of the different materials is carried out. The main aspects affecting the practicality of reuse is the demand and supply patterns. By investigating the most common demand patterns, it's easier to understand what is expected and demanded by customers in the industry. The supply patterns are as important to investigate to understand how to procure the materials, what logistics that needs to be considered and the regulations affecting the processes.

3.1 Framework for evaluating practical aspects

Certain factors impact the practicality of reusing specific materials and components. To assess their feasibility, a framework for evaluating different materials will be created, considering different aspects that affect these reused materials. The framework is divided into demand and supply aspects. The main categories that will have an impact on the evaluation of materials are shown in *Table 3:1* since these are identified as the most important aspects to consider. These aspects will together form the framework on which different materials can be evaluated from. Since several of the aspects affect both the demand and supply side, a form of separation is needed to address each of the aspects both from a supply and demand perspective.

Table 3:1 Framework for evaluating practical aspects of reuse, demand and supply aspect.

Demand Aspects	**Supply aspects**
Environmental	Procurement Of Materials
Cost Savings	
Logistic	Logistic
Regulations And Certifications	Regulations And Certifications

The result of the framework will be presented in a matrix presented in *Figure 3:1* where materials with favourable supply patterns will be presented in the right part of the matrix, while materials with favourable demand patterns will be presented in the top part of the matrix. The evaluation is based on the different aspects presented in *Table 3:1*.

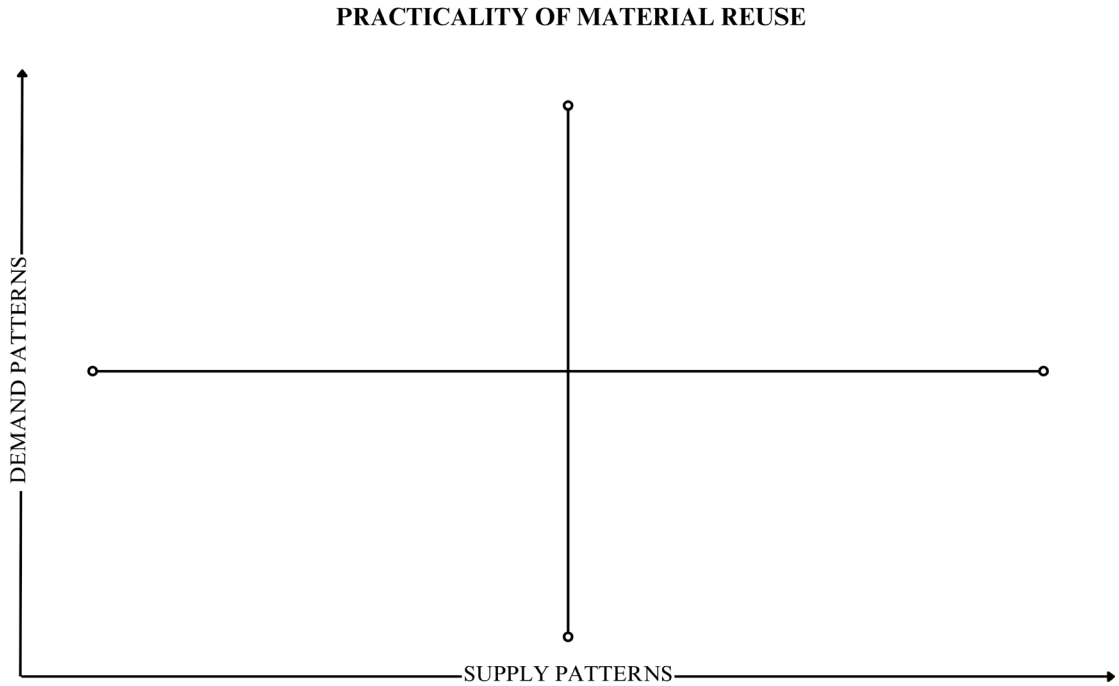

Figure 3:1 Matrix for assessing different materials practicality for reuse.

The construction sector has multiple different categories of building materials and some sort of limitation is needed to perform a thorough and concise evaluation. Based on data from Derome of their main categories of goods as well as data from the excel file "*Checklista Återbruk*" (Göteborgs Stad, 2025) the most relevant categories of building material can be identified and used as a basis for the further evaluation of reused building material based on the set of demand and supply aspects. These categories are presented in *Table 3:2* with examples on what specific type of component or material it could equal in each category, however the category might contain other components or materials that are not mentioned in the subcategory.

Table 3:2 Main categories and subcategories of construction materials that will be evaluated.

Main Category	**Subcategories**
Paving materials	Paving stones, curb stones
Wall and roof cladding	Bricks, slates, roof tiles
Constructions of ready to assemble elements	Joist, hollow core slabs, glulam beams, concrete foundation
Material sold per length unit, wood	Studs
Material sold per length unit, steel	Structural beams, Studs
Boards in different materials	Plywood, OSB, Gypsum
Complete components	Doors, Windows, kitchen
Furnishing and trim	WC/sink, suspended ceiling tiles, textile carpet
Insulation	Stone wool, glass wool, PIR, cellular plastic
Technical installations	Cable ladders, radiators, ventilation ducts, luminaries
Materials used in temporary constructions	Steel beams, white goods, timber for castings, Masonite, doors etc.
Excessive/Saved materials	Boards, studs, insulation, tiles etc.

3.1.1 Demand aspects

It is important to understand the demand aspects to evaluate different materials suitability for reuse. The reuse market is not a large market today, but there are examples of projects where reused materials have been used and the demand for them are increasing. The most important demand aspects when discussing using reused materials are their climate impact, potential cost savings and laws & regulations, forcing actors to reduce their climate impact in construction projects. The logistical aspect is also affecting the demand for materials since it needs to be easy to handle the materials as well as making sure that they have the right documentation. All these aspects must be considered when evaluating materials and could show which groups are practical to reuse seen from a supplier perspective.

The market for reused materials has expanded over the last years. Historically, these materials have been used in renovation projects but the demand for reused materials for new construction projects has increased as well (NCC, 2025; Peab, 2024). This is mainly due to higher environmental demands for the projects and companies. The most common materials to reuse have been construction components such as doors, windows, floor materials, furniture, porcelain while construction materials such as plasterboards, plywood, and timber are relatively uncommon to reuse even though it is fully possible to reuse (Van Uden et al., 2025; Miliute et al., 2021). Timber shows to be possible to dismantle and reuse, although it might need to be controlled visually

(Strand Nyhlin & Åfreds, 2022). Since the demand for reused materials are increasing, it is important to analyse the most crucial demand aspects to give suppliers an advantage when incorporating reused materials into their assortment.

3.1.1.1 Environmental impact

Higher environmental demands forces clients to think more circular. Since most of the carbon emission comes from producing new construction materials, clients are examining the possibility of using reused materials to lower the climate impact. The largest climate impact in a building often comes from the structural elements since they cover a large part of the construction materials. Structural elements such as steel beams and hollow core slabs have been reused in construction projects, showing a large decrease of climate impact (Strand Nyhlin & Åfreds, 2022). A preferred structural element is steel products since it keeps its quality over time better than many others.

Every material that are being reused is one less component that needs to be manufactured and therefore every reused component equals environmental savings. However as mentioned, steel and metal have the highest environmental impact as well as components made of concrete. Other materials such as timber have less environmental impact (Hedén & Sande Beiro, 2019). While some actors believe that the materials with the largest climate impact should be reused, others focus on reusing everything that can be reused to lower the total climate impact of the project.

3.1.1.2 Cost savings

Rakshan et al. (2020) identifies cost savings as another key driver for reuse, as reusing construction materials can be more economical due to lower material costs and reduced landfill fees. Additionally, an expected price increase in virgin materials may further drive demand for reused materials (Van Uden et al., 2025). Renovation projects may be more suitable for reuse than new construction, as they often require smaller quantities of materials, making reuse more feasible and leading to greater cost savings (Wennesjö et al., 2021). While new construction projects can also benefit from cost reductions through reused materials, high logistical costs may present a challenge. Clients and customers are today not willing to pay more for a reused product than a new but there are several examples of projects where the reused materials have been sold for the same price as new materials. The cost savings is not the main driver today for reused materials, it is mainly considered as a bonus in cases where it has been cheaper to use it. Studies are also expecting the prices for reused materials to decrease when the reused market is more established while others think that reused materials will be more attractive over time, resulting in higher prices. Mamo Fufa et al. (2023) suggests that manufacturers and suppliers of new materials should be involved in the reuse process to help reduce costs as they can use their current processes and customers, and this would increase the demand and facilitate the usage of reused materials according to the authors.

3.1.1.3 Logistical aspects

The demand of reused materials from a buyer or client's point of view can differ depending on what type of logistical aspects that are associated with the specific material and to which extent these logistical aspects needs to be considered. A lot of construction projects today are complex where there are numerous deliveries to the construction site simultaneously throughout a week or day (Sveriges Kommuner och Regioner, 2023). When dealing with reused materials it is important that the correct amount of material demanded arrives at the right time with the right quantities and with proper packaging to protect it from weather or wind since the materials may be stored outside before use. It is also important that the products have the predetermined quality so that the contractor don't have to spend time sorting out inadequate materials.

In addition to this it is important for the customer to be able to demand the right information and traceability on the reused materials. This helps contractors to document every component in the building which often is standard today through different systems such as: Byggvarubedömningen, BASTA or Sunda Hus. The quality and accuracy of this data and information could be a crucial factor when ranking the demand of different reused materials from a logistical standpoint. Some materials are easier to document and is therefore easier for a contractor to trace back to the origin which often is something that is needed in a construction project today. In addition to this, projects that implement take back system where the contractor is offered to return excessive materials or materials that can be reused is on the uprise (Jansson, 2023). This adds further complexity to the logistic aspects where the contractor needs to have systems in place to handle these situations. However, the opportunity for the contractor to send back materials could increase the demand for reused materials. If the contractor can send back materials, they can lower the climate impact of the project since less materials go to waste. If a supplier could offer these take back systems, this could be a driver for increased demand of reused material.

3.1.1.4 Regulations and certifications

There are several regulations and certifications playing a crucial role in the demand for reused material, these could be a major driver when it comes to implementing reused materials on a larger scale. In 2022 the requirement to do a climate declaration on every construction project was introduced in Sweden (Boverket, 2024b) and in addition to this, EU are pushing for implementing several new rules and regulations such as the Corporate Sustainability Reporting Directive [CSRD] (Jansson & Pålson, 2024). Depending on the structure of the regulations, different materials could be demanded more than others, and it is crucial to know how different materials will be affected by these regulations. Today there are no legal requirements for implementing reused materials, in the future this could change leading to an increased demand for reused materials. There are although some regulations today, functioning against the implementation of reused materials in new construction in Sweden. The building permit does not give any room for flexibility of façade changes, which means that all reused

materials need to be found at an early project stage. This is often not possible which complicates the use of reused materials. Availability requirements, sound and fire demands also complicates the use of reused materials. In July 2025, a new version of Boverkets Byggregler [BBR] is released, aiming at facilitating for innovative solutions by formulating functional demands instead of detailed documentation on how it should be executed (Boverket, 2025b). This will hopefully facilitate for more use of reused materials and components.

Warranties and quality assurance

Warranties and quality assurance is always important for a contractor or buyer of building materials. For them it is often more preferred to purchase a new product to get the relevant warranty, often up to 10 years on building materials. In the case of a construction project, it is the contractor who has the responsibility of the work, and the products used (Byggandets kontraktskommitté, 2007). This makes the contractors hesitant to buy and implement reused materials because of the uncertainty of the product and the lack of warranties on the products. To resolve this issue, in some projects the contractor's responsibility is altered to just account for the work that has been made and not the products themselves (Klimatarena Stockholm, 2025). This makes it easier for the contractor to implement reused materials since they don't need to take full responsibility of the material. In these cases, the client carries the responsibility of the reused materials.

When it comes to different materials, there are higher demands of documentation for reused structural elements to ensure their quality. If there is full traceability of a reused structural steel component, a visual control is enough to ensure the right quality but if there is no full traceability, a chemical analysis needs to be done of 10 percent of the products to ensure their quality (Husson & Lagerqvist, 2018). In addition to this, when there is lack of documentation, destructive testing needs to be done to determine the material properties of the steel components.

Climate declaration

The climate declaration consists of different levels and phases. At present, it is demanded to include the climate data from the production stage. This stage is divided into 5 separate parts A1-A5 (Boverket, 2024b). The parts A1-A3 contains climate impact due to the raw materials, transport and production of structural components, building envelope and non-structural walls. All other components are not part of the climate declaration. A4 requires the climate impact connected to the transport of materials and products from the manufacturing plant to the construction site. A5 are divided into two parts where one part is the construction waste on the building site.

In this section the climate impact from all the materials that go to waste should be presented and it contains both the production stage and the transport stage. Relevant for the reuse market is to decrease this section of waste material and therefore be able to

subtract this impact from the climate declaration of the project. If waste or overordered materials are sent back to the supplier or reused in another project the clime impact from these specific materials should not be included in the original projects climate declaration which benefits the project overall (Boverket, 2024a). By using reused materials in new construction, the climate impact of stage A1-A3 will decrease since these materials accounts for 0 $kgCO_2eq$ in the production stage. To reduce the waste and therefore create a better climate declaration could be a good incentive to increase the demand for reuse and send back more material to the supplier.

Corporate Sustainability Reporting Directive (CSRD)

The new directive of corporate sustainability reporting was implemented during 2024 and will be applicable to companies with stricter reporting directives over the years to come. It consists of requirements such as more detailed sustainability reporting in the annual report. The impact on environmental and social sustainability as well as double materiality assessment (European Commission, 2025). Although it is hard to say what effect the new reporting directive will have on reused building materials it is evident that more clearly stated directives and information transparency is needed for companies to be able to work with reuse on a larger scale (Jansson & Pålson, 2024). CSRD could be a start for more common comparisons and could therefore increase the demand for reused materials and in the longer run put pressure on clients and buyers to implement more reused materials.

3.1.2 Supply aspects

There are several factors affecting the supply aspects for reused materials. Materials that have been mounted in another building need to be dismantled before being available for supply, while excessive materials often are available on site and in no need for dismantling before it can be resold. These factors affect the practicality for reusing certain products and how suppliers can procure them. Today there are several minor suppliers of reused materials who specializes in different areas. Some are specialized in adaption of new offices where lots of different materials of old offices are inventoried and transported to a reuse hub where it gets resold to customers within their network (Rebygg, 2025) while others are specialized in gathering specific materials and sell them as reused (ecophon, 2023; Brukspecialisten, 2025). Suppliers for reused construction materials have also been established the latest years (Åfreds, 2025c; Wiklunds, 2025; Spirec, 2025) focusing on reusing construction materials that otherwise would go to waste. The logistics for gathering and supplying materials affect which materials are possible to supply. Regulations and certifications connected to the materials also affect the practicality of reusing them which need to be considered while evaluating the materials.

3.1.2.1 Procurement of materials

Reused materials can be categorised into saved/excessive materials and dismantled materials. Saved/excessive materials are materials that have been used but not mounted in a building structure while dismantled materials are those that have been used in a prior building and needs to be dismantled before being available for reuse. According to a study by Wennesjö et al (2021) it is assumed that about 1800 tons of interior construction components are available for reuse yearly in the Gothenburg region from adaption of offices. The main products are floor mats and ceiling tiles because of the large quantities as well as their large reuse potential because of a long technical lifespan and they are easy to dismantle. Textile carpets, windows, glass sections and doors also have a large reuse potential. *Table 3:3* shows an estimate of the amount of possible reused products yearly from adaption of offices in the Gothenburg region based on the report "*Etablering av en storskalig marknad för återbruk i bygg- och fastighetssektorn"* by Wennesjö et al (2021).

Table 3:3 Predicted amount of reusable products associated with tenant fit-outs in offices in the Gothenburg region, rounded to nearest ten, from the study "Etablering av en storskalig marknad för återbruk I bygg- och fastighetssektorn".

Product type		**Units/year**	**Unit**
Inner doors		3810	Pieces
Glass sections		13790	m^2
Textile carpets		115650	m^2
Wooden floor		24160	m^2
Luminaires		13700	Pieces
Suspended ceiling tiles		107790	m^2
Pentry	Cabinet carcasses	950	Pieces
Pentry	Cabinet doors	1340	Pieces
Pentry	Countertop	850	m
Pentry	Kitchen sink	120	Pieces
Pentry	Fridge/freezer	240	Pieces
Pentry	Dishwasher	240	Pieces
Pentry	Microwave	480	Pieces
WC/RWC	Toilet	820	Pieces
WC/RWC	Sink	820	Pieces
WC/RWC	Mirror	1370	Pieces
WC/RWC	Hooks	1370	Pieces
WC/RWC	Soap dispenser, trash can, sanitary bag holder	1370 each	Pieces
WC/RWC	Toilet paper holder	970	Pieces
RWC	Grab rail for accessible toilet	60	Pieces
RWC	Shower mixer	60	Pieces

The possibilities for reusing materials depend on factors such as project type, contract form, and location. Except from materials from adaption of offices, façade materials

are also commonly reused. Andersson et al. (2021) highlight the significant availability of bricks from demolition projects, emphasizing their high reuse potential. Similarly, Wennesjö et al. (2021) highlights that paving stones and paving bricks are easy to dismantle and reuse, contributing to notable environmental savings and reduced waste.

Construction materials are often harder to dismantle compared to interior products and components and there are different opinions whether construction materials are applicable for reuse. The quality of old plaster boards and studs could be deteriorated after dismounting, but studies shows that the first layer plasterboard in constructions with 2-layers plasterboards are often in good quality and fully useful to reuse (Rakhshan et al., 2020) while Göteborg Stad (2025) suggests that plasterboards are not applicable for reuse due to spackled joint, making them hard to separate. But in a large reuse project in Uppsala, they managed to reuse 110 tons of plasterboards by using a tool called *Screwfinder*, which worked as a magnet to find the screws behind paint and spackle. The result showed that it was easy to reuse the plasterboards, and the first layer plasterboards kept the same quality as new materials (Strand Nyhlin & Åfreds, 2024) while the second layer were grinded and the other side of the board was used in the new construction. NCC and Sundolitt are also showing that insulation could be reused after they dismantled cellular plastic from a roof renovation of Norra Älvsborgs hospital (Åfreds, 2025b), the insulation were then tested by Sundolitt and delivered to a new construction project where it was used for ground works.

Excessive materials, in contrast, are often available on-site and do not require dismantling before resale. These materials are frequently overordered or used for temporary construction purposes, such as plasterboards and studs, which are typically in good condition and suitable for reuse. Bygg Ole by Beijer Byggmaterial has successfully implemented a reuse system for timber, sourcing wood from local recycling centres and construction sites where it has been used for temporary structures like moulds for casting, barriers, and stairs (Åfreds, 2025c). One challenge in this process is finding labour to clean the wood by removing nails and screws, which can be time-consuming.

The materials can be collected through cooperation with demolition-companies or deconstruction companies that are specialized in dismantling materials. Excessive materials can be sorted out by construction firms at the construction site where it can be collected.

3.1.2.2 Logistical aspects

The logistical challenges are a central part of working with reuse and are often complicated since there are no guidelines and set rules for how to deal with reused materials from a logistical standpoint. A supplier needs to be well informed and have processes in place to be able to deal with reused materials and its challenges. As a supplier of reused materials, a process needs to be set to collect the materials. It is also

important to quickly find an end customer for the collected material, to decrease the risk of timely storage resulting in excessive costs. The packaging of materials and transportation is an important aspect that affect the overall logistics as well as the storing of materials. The logistics is essential to study to understand which materials are suitable for reuse.

Packaging and transportation

To collect materials that could possibly be reused, either materials that have been dismantled or materials that have been leftover needs to be taken care of at the site and then transported. What differentiates reused materials from newly produced is that they do not have any packaging and are not prepared for any transportation or handling (Sveriges Kommuner och Regioner, 2023). This is especially crucial when dealing with products that are very fragile such as windows or doors. To transport these, specially made racks or containers must be in place. For other materials such as plaster boards that are delicate and sensitive for moisture and weather, other type of packaging and preparation before transportation is needed. Here it is important to decide who should be responsible for these parts. Should it be the contractor or the organisation taking back materials such as a material supplier.

When it comes to transportation, several measures need to be in place to handle the transportation effectively. First of all, the drivers need to be educated and informed about the goods they are loading and transporting. A system for when and how these transports should be booked is also crucial. In addition to this it might be necessary for the driver to perform an ocular inspection as a first step to identify material that might not be suitable for reuse. It has been shown in building projects in general that contractors might try to hand over materials to suppliers for reuse that might be waste or even hazardous waste.

Storing and traceability

When materials are delivered to the storing place which often in present time is some form of a reuse hub but could in the future be incorporated into a supplier's normal warehouses or reuse terminals, different actions and measures needs to be taken. Firstly, there needs to be suitable storage equipment for the different materials. In addition to this, the materials often need to be cleaned or stripped from nails, screws or other contaminants before they can be sold or distributed as reused material. While storing, some materials need to be stored in a heated area while others need to be stored laying down on a flat surface to avoid altering its shape over time (Sveriges Kommuner och Regioner, 2023). Knowledge and cautiousness are crucial, and proper education is essential for the people working with the materials. This is something that would benefit existing material suppliers since they already have the proper knowledge and handling of their material. The transition to managing reused materials can therefore be relatively smooth, especially since much of the existing logistical infrastructure can be leveraged.

Something that should be implemented which suppliers today might not have in place when it comes to reused materials is some form of data on the materials and traceability. This would create an easier process in which the reused materials can be traced over time. This is often something that is asked for by the end customer. By being able to provide the right documentation and full traceability on the reused material it is easier to sell and to attract new customers.

3.1.2.3 Regulations and Certifications

A main issue in the suppliers work for reusing of building materials is the laws and regulations they must follow when it comes to managing and selling products. The last years several laws and regulations have been implemented in practice with more expected to follow. Information regarding specific products is important for the suppliers to be able to offer reused products, a key aspect is the environmental product declaration EPD. Beyond environmental data, it is also important for a supplier to be able to provide clear information about the quality of the products and plausible warranties, or if warranties are not possible, clarify how responsibility and liability are managed.

Warranty and quality assurance

There are a lot of uncertainty in the industry on how to deal with warranties and quality assurance when a supplier provides and sells reused materials. In the projects where reused materials have been used, one solution is that the supplier provides warranties in the same way as for new products. Danish reuse company A:gain provides warranties on all their new products and is therefore more attractive from a contractor's point of view. Bruksspecialisten is another company that works with reused bricks and is one of few companies that can offer CE-certification for their products (RI.SE, 2025). This means that customers can implement their products in normal contracts such as ABT06 which increases the attractiveness for reused material. A supplier of reused materials has therefore the opportunity to offer documentation, functional description and warranties. But it is not always possible to offer warranties on the items due to lack of product documentation. In these cases, the project has solved the warranties internally, often the client waives the warranties because they have enough information about the product to trust the quality. The contractor can in these cases put warranties on their work but not on the materials (Strand Nyhlin & Åfreds, 2024). In projects where the client reuses materials within their own projects, the warranties are irrelevant. There are also suppliers for reused structural materials (Stena Stål, 2025; Moelven, 2025). There are higher demands for warranties and quality assurance for structural elements. These materials need to be tested to ensure their capacity if there are to be used as structural elements in a new building.

Environmental product declaration (EPD)

Environmental product declaration (EPD) is now a widely used standard to provide information on products and their environmental data. It gives specific data on each material in different products and are therefore important components when conducting a LCA analysis or climate declaration for a building (Boverket, 2024c). Currently, there are no formal requirements to use EPDs or to specify how detailed they need to be. This makes it important to include information about the type and accuracy of the data, known as Q-metadata. Still, many clients now request EPDs in their tenders, and they are increasingly becoming a standard practice in the construction sector.
When it comes to applying EPDs to reused materials, there is a lack of information on how to properly account for the fact that these materials have no additional environmental impact since they require no new raw materials or manufacturing processes. Stena Stål is one example of a company who has succeeded to create a new EPD for a reused product, in their case it is a steel beam (Stena Stål, 2024). By doing this they lower the CO_2-emission by 95 percent compared to a beam of scrap-based steel and gives a value of 53 $kgCO_2eq$/ton compared to their normal beam of 674 $kgCO_2eq$/ton. This shows the potential of working with reused materials in the product declarations to provide accurate information about materials with substantially lower climate impact.

Regulations concerning handling of waste

Reused materials are affected by several different laws and regulation. One of them is the Swedish environmental law. According to the Swedish environmental law chapter 15 §1 (Miljöbalken SFS 1998:800, 2025), material is classified as waste if the possessor of the material is disposing it, intending to dispose it or is obliged to dispose it. If material is classified as waste, it is more complicated to reuse it because it is affected by the Swedish waste regulation which concerns handling, traceability and documentation of all material, classified as waste. It is therefore important to avoid that the reused material gets classified as waste, and keep it classified as a product throughout the process (Avfallsförordningen SFS 2020:614, 2025) since reclassification from waste to a product is a complicated process. This need to be considered, especially for excessive materials from construction sites which easily can be classified as waste. Thorough documentation of condition and use of the materials are important to make sure the right material classification remain.

Boverkets byggregler [BBR] applies on reused materials, and the distributor of the reused materials are required to determine that the products fulfil the right technical requirements as new materials (Boverket, 2023) which means that some materials need to be tested to ensure the right quality, especially structural elements. Produktsäkerhetslagen SFS 2004:451 (2022) also impacts reused materials by ensuring that all materials are safe to handle. This means that all reused materials must be inspected, and any relevant information regarding usage limitations must be documented and communicated to the end customer.

3.2 Framework for evaluating financial aspects

The demand for reused construction materials is increasing, but the financial benefits for companies that aims at including reused materials in their business are not obvious. Today, the reuse process has mainly been handled by real estate companies, municipalities, contractors, or external reuse consultants. Material suppliers have not been able to expand their business to include a reused assortment. This is mainly due to costly logistics and storing, making it hard to make the reuse business profitable. This also makes it hard for suppliers to provide competitive pricing for reused products (Oyedele et al., 2014). To study the profitability aspects of reuse, the market share for different materials will be studied. This will form a basis on which the different materials will be evaluated based on their dismantling, handling and regulatory cost as well as the possible selling price. The result will hopefully show what materials a construction material supplier should focus on when offering reused materials.

The framework mentioned above will be presented in a graph with market share on one axis and the cost connected to the product on the other axis based on, dismantling, handling and regulatory cost, see *Figure 3:2*. This will resemble a Growth Share matrix but with the modification that the market growth rate will be replaced with the total indirect and direct cost of the product. The growth share matrix often tends to neglect new innovative products and with reused building materials being one of them it is important that the graph is adjusted to account for those as well (Baker, 2025). The market share will be represented by the relative market share estimated based on selling data from Derome as well as estimated market share of reused materials from interviews and literature.

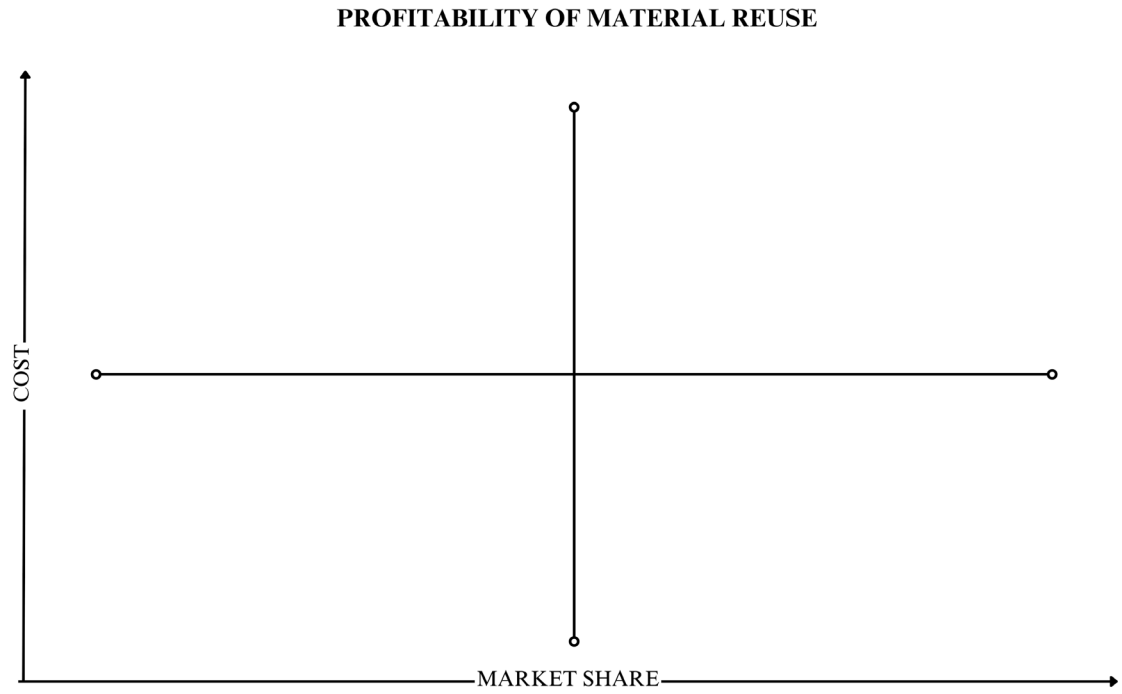

Figure 3:2 Matrix for assessing the profitability of different materials based on associated cost and their market share.

3.2.1 Market Share

To be able to evaluate the financial aspects and profitability of a material it is important to analyse its market share. Products with a higher market share can provide greater value for a company and it is often considered the most important products. However, these products are also often considered as having a high market concentration which could result in high prices and a low degree of innovation (Konkurrensverket, 2021). This could hinder the development of reused building materials and act as a barrier for scaling the circularity in construction. It is important to analyse these high market share products to identify their potential when transforming towards a reuse market. Today there are no mature reuse market in place, and it is therefore difficult to evaluate the market share of reused materials. It is therefore important to analyse the market share of new materials that are being sold to construction projects to be able to identify potential high market share products that could be suitable for reuse.

3.2.1.1 New Materials

Looking at new materials in construction projects, the largest quantity of material is for the structural parts of the building. The most common structural materials are concrete, steel and wood. Concrete is the most common structural material (Autodesk, 2025; Clark, 2024) because of its versatility and strength. Because of high carbon emissions from producing concrete, other structural materials as wood have increased in popularity and there are several multi-story buildings today built with a wood structure. Common substructure materials are wood, steel, plasterboards, insulation, plywood, chipboard etc for the interior while facade and roof materials are used on the exterior.

Large suppliers of construction materials sell a high amount of these materials yearly, and the demand for these products will remain, showing the importance of investigating whether these materials are possible for reuse. A lot of these products are also sold at relatively low prices because of their large quantities and relatively low manufacturing prices. This is crucial to consider when evaluating materials that could be suitable for reuse. If a new material is sold at a low price and has little material value, it may not be economically viable to reuse.

3.2.1.2 Reused Materials

Due to the immaturity of the reuse market, there are no information on how high volumes of each material are reused today (Boverket, 2024d) but the possibilities for reusing materials are large, assuming that the industry will be better at facilitating for it. Reuse of structural parts are relatively uncommon today because of the need for quality testing to determine their technical properties and there is often a lack of documentation of the prior use of the products. Stena Stål have developed their reuse business and are offering the same quality assurance for their reused steel as their new steel (Stena Stål, 2025), facilitating for more reuse of structural elements. Another innovation project in Gothenburg, Kv. Återbruket are reusing hollow core slabs from an old IKEA building, showing the possibilities for reusing structural elements, but these parts cover a small part of the reuse market today. The most common materials to reuse are components as windows and doors (Strand Nyhlin & Åfreds, 2024). Textile carpets and suspended ceiling tiles are also commonly reused. For new construction projects, façade materials, suspended ceiling tiles and paving stones have been reused in some projects. These materials are easy to dismantle and most of their technical properties are kept while reusing them. There are also existing suppliers of these products, making it easy to purchase the materials. According to national marketplaces for reused materials, there are a large supply of brick, suspended ceiling tiles, insulation, luminaries available but there is a wide spread of materials, making it hard to determine the most common materials.

3.2.2 Costs

The second factor to consider when evaluating the financial aspects of reuse is the costs associated with specific reused materials. This consist of multiple different partial costs, but the crucial ones are the cost of dismantling and procuring materials, handling and logistics of the reused materials and regulatory costs, such as quality testing or certificating. These costs will presumably lay as the foundation for the possible selling price, considering possible margins that the supplier of reused material are requesting.

3.2.2.1 Procure/Dismantling

The process of dismantling materials is in general much more complicated than traditional demolition and is often seen as a more expensive option than demolition. However, there are factors often overseen when comparing these two options

(Deconstructors Demolition Inc, 2025). The primary factors is the magnitude of the structure that are being demolished or dismantled. If the building is in quite good condition, it might be more cost-effective to dismantle it because of the value of the products that can be reused. In addition to this the fees for waste are often substantial which may make it more beneficial to dismantle.

The cost of dismantling and procuring different building materials depends heavily on the amount of work and time needed to acquire the materials. Material that needs labour-intensive dismantling such as plasterboards or other built-in components require much more time, contributing to higher costs. Excessive building materials that have not been mounted or installed demand less labour while acquiring them which saves time and money. This can be an economic incentive to focus on excessive materials and not on complicated built-in materials.

3.2.2.2 Handling

Reused construction components such as doors and windows often require refurbishment to meet the project-specific requirements. This can be done by repainting the doors and windows, but other requirements can make the process more complex. Windows often require refurbishment to meet modern energy requirements either by changing the inner glass to a new energy efficient glass or by adding an extra glass to the window. A problem when reusing complete windows is that there is often a leak of the gas in a sealed window, in these cases new gas needs to be added when refurbishing the window (Strand Nyhlin & Åfreds, 2022). The renovation could be more cost efficient than changing the whole window depending on the size of the renovation. For construction materials as timber, screws and nails need to be removed from the material, which is time consuming and a big challenge (Åfreds, 2025c), but the technical properties in wood are often kept. The handling costs for structural elements are more expensive due to higher demands for quality testing to meet the industry standards and strength requirements for the structural elements. Structural calculations also need to be made for the structure to investigate how the reused elements are affecting the load bearing structure.

3.2.2.3 Regulatory cost

There are several rules and regulations affecting the use of reused materials. These rules and regulations often result in additional cost or labour. A good example of this is the extra cost of quality testing as mentioned. In addition to this a lot of extra cost regarding the regulations is connected to the waste and environmental laws that now often hinder the reuse market. Reclassification from waste to product is often tedious and time consuming which often make people and companies hesitant about implementing these techniques.

In addition to this, the cost and time of changing building permits and design proposals in order to accommodate for small changes that might occur when implementing reused

materials is also something that affects the overall cost for reused materials. Overall, the biggest cost associated with regulatory issues is often the extra time needed for implementing reused materials since the processes are not in place as for the usual building materials.

4 Methodology

The study was made with a qualitative mindset since there was lacking information and references on the specific subject of reuse from the supplier perspective. The work started by broadly researching literature to get an understanding of the subject. Since the research area is still in its infancy the literature was used to create a framework on which the basis of the analysis of the practicality and profitability in reused materials was made. It was not used to provide detailed insights and answers to the specific research questions. Further on a substantial part of the analysis and results was made with interviews as basis. In addition to this, to complement the interviews and qualitative data some quantitative data was collected to support and validate the statements gathered in the literature and interviews. In the end the results were applied to the framework developed in the literature. By doing this the authors could present a clear result to the research questions. Thereafter the results were further discussed and developed to account for uncertainties and future considerations.

4.1 Derome

Derome is a large company active in the construction industry. The company is divided into six different business fields: Timber, Construction & Industry, Wood engineering, Housing, Real estate and Andersson Haus & Dach (constructing roof trusses for the German market) (Derome, 2025). The company is thereby active in the whole chain from forest to complete building which is unique for this company. The study was conducted in cooperation with Derome Construction and Industry at their department for large customers. Derome Construction and Industry is active in Skåne, Blekinge, Småland and along the Swedish Westcoast where they have 50 facilities with selling of construction materials. Derome is in the early stages of implementing a reuse business in the Gothenburg region as a way towards climate neutrality in their value chain by 2045. They have a large assortment of construction materials, and their major sales comes from selling of wood materials. Customers to Derome Construction and Industry is construction companies, both large actors and smaller construction firms. They sell materials for new construction as well as renovation projects.

4.2 Literature study

The literature has been found through a range of different search methods and portals and includes a range of different references such as books, reports, news articles, blog posts. For the academic sources, Scopus and Google scholar was used with search words focusing on reuse from a supplier perspective and with specific focus on building materials. Literature with origin in Sweden was mainly used since the topic of reuse has been addressed during a longer time in Sweden than in other countries and with more relevant references. In addition to electronic literature, books have also been used

as a source of information. These books have targeted specific issues related to reuse and have been a good complement to the other sources of information.

The literature helped identify the areas of interest when discussing supply and demand aspects of reuse as well as the questions of what materials are the most practical and profitable to reuse. This helped to build the structure which would later become the framework for evaluating the materials. The literature also gave some first insights into which materials should be focused on and helped structure the material groups that was later used throughout the whole study.

Due to the limited literature available on this subject compared to other research areas, the scope of sources was expanded to include more informal material and literature. These references included news articles, blog posts, social media content, and various websites. To ensure credibility, all the informal references were cross-checked against each other as well as academic references. Informal sources were primarily used to understand the current state of the sector regarding reuse, as well as the challenges and opportunities it presents.

4.3 Interview study

The interviews were based on the framework developed in the literature study. With a starting point in the different sections of the literature study the interviewees were chosen. The persons were chosen to accommodate for a broad spectrum of information that was needed to deliver a good overview of the research questions. The number of chosen interviews was made to accommodate for all the different sections of the literature framework, and the goal was to find interviewees with special knowledge within each area to be able to compile the different knowledge into one result. This resulted in 14 interviews see *Table 4:1*. To find suitable interviewees tips and contacts were retrieved from supervisors and from people with knowledge in the sector. The interviewees have mainly been people that are interested and working with reuse daily. This could result in some biasness due to the fact that many people that work with reuse have the topic as an interest and their view of reuse might not reflect the general opinion in the construction industry.

Table 4:1 Role, company and label on each interviewee.

Label	Company	Role
Contractor		
C1	RA Bygg	Site manager
C2	Vestia Construction Group	Business manager
C3	TM2	Site management
C4	Peab	Environmental coordinators contractor engineer
Suppliers		
S1	Beijer Byggmaterial	Project manager
S2	Wiklunds	Concept manager
S3	Spirec	Owner
S4	Stena Stål	Reuse Specialist
Demolition company		
D1	Demontera	Project manager
Consultants		
CO1	Nymiko	Project manager
CO2	Akuro	Sustainability consultant
CO3	Sortera	ReUse manager
Internal communication		
IC1	Svensk Bygglogistik	CEO
IC2	Derome	Sustainability manager

Because of the complexity in the research field of reuse in the construction sector, a semi-structured format was applied to the interviews were questions and guidelines were set beforehand but with room for adaptability and flexible changes throughout the interviews. The questions that were determined beforehand was divided based on what role the interview person had. The interview questions were made based on information from the literature interview. For interview questions related to contractors see appendix A, for Consultants/Project Managers see appendix B and for suppliers see appendix C Since the subject is immature and with many uncertainties a majority of the question were open-ended with room for follow up questions to clarify or broaden the understanding about specific issues.

The interviews were held online or in person depending on the circumstances which led to an even distribution between on site and online interviews. They were in general between 30-60 minutes depending on how much information was processed. Every interview except 4 were recorded and transcribed after consent with the interviewee. The transcription was saved by the authors and documented separately. Before publication all the interviewees had the possibility to review the report and suggest changes or remove any unwanted information. The interviews that were not recorded was due to the setting and meant that the questions were asked during a walk around on site or in a larger meeting which made it hard to record, therefore written notes were

instead used to document these interviews. A decision was made to not include specific names of the interviewees but instead provide the reader with the company and the role of the interviewee which was believed to be sufficient information for the reader. This was also decided to make the interviewees feel at ease with the information they provided in combination with the possibility to revise the report before publication

The information collected in the interviews were analysed and structured depending on what relevant information it consisted of. Demand and supply information were separated and categorised into their respective aspect as well as the information related to the profitability of reusing varied materials. The interviews provided a major part of the results in this study. The interviews were shown to be a really good support for the framework since many of the key points identified in the literature was also brought up by the interviewees. The interviews helped the authors realize what materials are the most practical and profitable. They also provided impactful quotes that could be used in the results. The questions chosen for the interviews was considered good and gave the study a much better understanding of the reuse sector today. The broad spectrum of interviewees and their roles also helped support the demand and supply aspects and gave good insights into the relationship between these two and the differences and similarities between different materials and the supply and demand patterns. Although it was in some cases difficult to ask about every specific material in the interviews but different interviewees had knowledge and information about different material groups which in the end resulted in a well-informed result on which a discussion could be held.

4.4 Site visits

The study was also complemented with four site visits, each lasting approximately one hour. Two site visits were at construction projects that had incorporated a lot of reused materials in their process and the other two was visits to warehouses that either stored or/and sold reused materials. These were performed to further broaden the understanding of how building materials are reused in practice and gave insights into what challenges and opportunities that arose when dealing with reuse on the construction site but also the logistics of these materials. These site visits gave valuable understanding on how people that work with reused materials daily feel about the topic and this was something that provided the authors with a good understanding of what was needed for further research and what the sector believes is the most necessary information that should be included in a research project about reuse from a supplier perspective.

The information from the site visits consisted of notes and reflections from the authors that were compiled and summarized. This informal type of information was on some occasions combined with more formal interview transcriptions when the setting and time allowed it. The information collected on the site visits both formal and informal was an important contribution to the overall report and result.

4.5 Informal data and meetings

A large contribution to this work has been through informal meetings and information exchanged through spontaneous interactions with people in the industry. This has been used as supplementary data. The authors have actively been present at the offices of Derome and has therefore been able to participate in informal meetings and information exchanges that otherwise would not had taken place. This information has helped the authors understand complex topics and in general provided an understanding to how the construction sector works with reuse today and what mindset suppliers have regarding reuse. This information is difficult to transcribe or record and have therefore mainly been taken by hand notes.

4.6 Quantitative data

To support and clarify the information given in interviews and literature some type of quantitative data was used. To identify the most demanded and supplied materials, sales data was used from Derome to identify these different categories of material. The data were also analysed to see patterns on what the most profitable materials to reuse could be. In addition to this, data on transport and storing cost was provided to be able to perform analyses on the logistical cost of reusing different materials. The quantitative data allowed for relevant analyses and gave a tangible answer on some of the questions asked. Internal documents were also provided on the processes and plausible cost of implementing reuse on a larger scale which gave the authors a good understanding of the extent to which Derome want to implement reused materials in their organisation.

The quantitative data provided from Derome was not to be disclosed in exact numbers in the report and have therefore been modified to instead be presented in a context where the final result is showed clearly but without showing any sensitive data. This has been verified with the relevant persons at Derome to ensure that no classified data or information has been disclosed in the report that may affect Derome and their affairs.

4.7 Ethical considerations and AI disclosure

The study aims at studying an important solution for enhancing circularity in the construction sector with a focus on improving resource efficiency and sustainability. It also has the potential to raise awareness about the importance of sustainable practices and encourage stakeholders to adopt greener approaches. By investigating traceability and certification systems for reused materials, the study helps mitigate the risk of greenwashing. There are also several ecological benefits of the study, including waste reduction, decreased climate impact, and the preservation of ecosystems.

Objectivity and transparency are paramount when doing a research project to ensure the credibility and trustworthiness of the report. This has been made by cross checking respondents answers to ensure that the opinions put forward in this report are objective

and ethical. To ensure this, full consent from every participant of the report was collected as well as multiple chances for the participants to revise and request changes in the report before publication. The secondary data provided from Derome has also been actively investigated to ensure its credibility. In some cases, secondary data may be considered less rigorous but in this case the advantages of having a specified dataset with many datapoints outweigh the drawback of it being a secondary source of data (Emerald Publishing, 2025). It would have taken too much time and work for the authors to produce this data on their own and have therefore resorted to secondary data provided by Derome.

AI tools have been used to improve quality of the thesis. ChatGPT have been used to improve text quality in some specific cases while not altering the writing style of the authors. Scopus AI have been used to find relevant scientific papers. All information provided by AI tools have been checked to ensure relevance and credibility. Personal information from interviews and through internal conversations within the company has not been shared in AI tools due to confidentiality. The AI tool provided by Chalmers to transcribe and analyse the interviews have been used to transcribe the interviews as well as separate different types of information from the interviews. The information added in the Chalmers AI tool were deleted after the information were analysed. The information has been checked against the original audio file in those cases that the transcription was unreadable.

5 Results

The main findings from the types of data collected: Interviews, Site visits and Quantitative data are summarized and presented in the following chapter. The result starts with a presentation of the different definitions of reuse and presents how this affects different materials and the reuse market in general. This is followed by a result of the two research questions and their framework. The first research question of practicality will be answered by the interviews whereas the question of profitability will include quantitative data as well to further support the result and analysis. The material categories and subcategories used for the analysis is shown in *Table 5:1*, however there might be additional materials not included in this study that in the future will be favourable for reusing.

Table 5:1 Main category and subcategory of different materials used in the study.

Main Category	**Subcategories**
Paving materials	Paving stones, Curb stones
Wall and roof cladding	Bricks, Slates, Roof tiles
Constructions of ready to assemble elements	Joist, Hollow core slabs, Glulam beams, Concrete foundation
Material sold per length unit, wood	Studs
Material sold per length unit, steel	Structural beams, Studs
Boards in different materials	Plywood, OSB, Gypsum, MDF
Complete components	Doors, Windows, Kitchen
Furnishing and trim	WC/sink, Suspended ceiling tiles
Insulation	Stone wool, Glass wool, PIR, Cellular plastic
Technical installations	Cable ladders, Radiators, Ventilation ducts, Luminaries
Materials used in temporary constructions	Steel beams, White goods, Timber for castings, Masonite, Doors etc.
Excessive/Saved materials	Boards, Studs, Insulation, Tiles etc.

5.1 Uncertainty regarding the definition of reuse

It is evident from all perspectives in construction sector that reuse is something that is not clearly defined, which is further supported in the interviews. The definition of reuse often differs from contractor to client or even between different positions at the same company as mentioned by both consulting managers CO1 and CO2.

> "*Framtiden and Stadsfastigheter use two different definitions of reuse. As a consultant, I use the term based on the project's definition. In Stadsfastigheter's definition, anything that would have been thrown away but isn't is considered reuse. So even if you ordered too much for a project, you could pick it up and use it elsewhere, that's considered reuse, even though the products are basically new. For example, there's a slide at project "Friländersgatan" that is new, but it didn't fit in the original project it was bought for. It would have been thrown away, but now it's reused instead. However, Framtiden Byggutveckling defines reuse as something that has already been installed in a building, then dismantled and reinstalled elsewhere. So, the definitions differ, even though both companies belong to the City of Gothenburg." – CO1*

This is reflected in what materials that are considered reused. In some projects it is enough for the material to have been delivered to the site but not used and for others the material must have been used in a building to be seen as reuse. This often results in a vague vocabulary regarding reuse that can affect material suppliers' willingness to implement reused materials in their business due to fear of greenwashing and backlash. There are although important to include all possible circular initiatives to lower the climate impact from the industry. According to S2, construction site waste is currently increasing rather than decreasing, which is an important issue that needs to be addressed:

> *"There's increasing pressure on construction sites, things have to move faster and faster, and that naturally leads to taking more and more precautions. You have to secure the material supply, because if a project stands still for even a day, it's a disaster." – S2*

This results in lots of new materials being leftover on site and after a while, discarded. The issues with overordered materials and excessive materials are a problem that needs to be dealt with to reduce the climate impact from the industry, even if there is an uncertainty of whether these materials should be categorized as "reuse" or not.

A step towards a solution to the vagueness of definitions is to separate materials depending on if they have been used in a building project or not. Two of the suppliers, S1 and S3 have made a decision about the definition. Over ordered materials and excessive materials being left on site are called "saved" or "overordered materials" and materials that have been used in a prior construction are named "reused" when and if

used or resold again. This dividing of materials makes it easier for the clients to understand the difference between reused materials and saved materials. S1 differentiates new materials from saved materials if the materials are ordered for a specific project and not stocked in their assortment, in these cases the client cannot return the products but S1 can take back the materials and sell them as saved materials.

Materials that have been used for temporary constructions are also mentioned in the interview study. Since these materials have been used for a purpose, it's classified as a reused material if used again according to the interviewees. S4 mentions that most of their reused steel comes from temporary constructions since the material have a long technical lifespan left. These materials have historically been wasted in construction project, even though the materials often are in good condition. In this study, temporary material is a separate category that includes all materials and components that are used during a limited time-period for construction works, site set-ups etc.

From the interviews the collective answer to who is responsible for what is reused or not are the client. Today, the client has the responsibility to decide where they draw the line of reused or saved materials. Whether they can include the environmental saving of using the material in the project or not is up to the client for each specific project. According to S1 they only deliver the material and give information on how much environmental impact the material has, and it is then the client's choice if they want to include this saving or not. A better definition of what materials that are included in the reuse definition is expected in the future according to the interviewees, aiming at minimizing uncertainty connected to the term reused materials.

5.2 What materials are most practical to reuse?

When assessing which materials are most practical for suppliers to reuse, both demand and supply aspects must be considered. There must be a clear demand for the materials, as well as feasible opportunities for suppliers to collect and distribute them. Interviews indicate a growing interest in reused products for both new construction and renovation projects. However, most of the interviews have primarily focused on new construction projects, involving both suppliers and clients to provide a comprehensive understanding of current market conditions. This section presents the interview findings, which serve as a foundation for evaluating the reuse potential of different materials.

5.2.1 Demand aspects

Historically, reused materials have been more commonly used in reconstruction and renovation projects, offering property owners a cost-effective renovation. As noted by C2, D1 and CO3 it is generally easier to circulate materials within reconstruction projects, which supports reuse efforts. However, there is now a significant rise in demand for reused materials in new construction projects as well. For suppliers, keeping pace with this development is important, as it presents valuable opportunities

to win contracts and grow their business in a market that is becoming more sustainability focused.

Which materials that are demanded depends on the customer. Some actors choose reused materials due to lower prices while others choose it due to the reduced environmental impact. Interviews shows that larger construction companies choose to use reused materials in new construction projects today with ambitious environmental goals and in pilot projects with demand for a certain amount of reused materials while private people choose to use reused materials to lower their costs. Regulations are also affecting the demand for different materials because the building need to fulfil accessibility requirements which requires different measurements and solutions. The building permit are also affecting the integration of reused materials since there is very low flexibility in the building permit process today.

The interviews show that construction companies request to buy reused materials in the same channels as new materials, showing the relevance for construction material suppliers to integrate reuse in their business model as cited by C2.

> *"Suppliers are super important, and this is a message to Derome. ... if I want to buy this product and, then they could say, 'Do you want it reused, or do you want a new product?' That would be the dream, really, because we handle the purchasing as a turnkey contractor and when we're sitting there making purchases, I'd really like to be able to choose that from the same place, can I choose it from Derome then? That would be great. Then I wouldn't need this middleman I usually hire separately. If Derome could provide that service, I think they could become more attractive as a supplier and player."-C2*

CO2 agrees with C2.

> *"I'm just thinking broadly and generally. In my projects, when we talk about reuse, quite frankly, I actually want to buy reused materials directly from the same supplier I buy new from. That is, the ultimate form of reuse."-CO2*

Even though there is a demand from large construction firms to buy reused materials, smaller firms and private people are the most important customers for suppliers of reused construction materials today as cited by S1 "*Right now, private people and small construction firms are saving us, they buy lot of these materials because they don't need large volumes*". For suppliers mainly selling excessive materials, small firms and private people are their main customers as well.

> *"40% of our customers are companies and 60% private people today and the company share have increased the past six months, it is not typically construction companies, it is mostly smaller real estate owners or farmers who*

does not have the same material discounts at the building trades as construction firms" – S3

With a larger assortment of reused construction materials, larger construction projects will be interested in buying reused construction materials instead of new materials. C2, who are active in a new construction project with ambitious reuse goals says that they have not discussed reusing construction materials as studs, boards etc but says that "*We need a business model in this, but if we can lower the environmental impact by choosing a different product, with the same economy, we choose the option that lowers the environmental impact*" and they mention that in these cases reusing construction materials can be interesting. In the following section, the environmental impact, cost savings, logistical aspects, regulations and certifications and the visual aspect will be discussed since these are key factors influencing demand.

5.2.1.1 Environmental impact

The most common driver for using reused materials today is to lower the environmental impact in projects. The rationale behind using reused materials varies depending on the end customer. For construction firms, real estate developers, and other stakeholders, a key motivation is the reduced climate impact since lifecycle stages A1-A3 for reused materials account for 0 kg CO_2 eq, making them a highly sustainable choice. Kvarteret Omställningen, a project in Gothenburg by Framtiden Byggutveckling halves its carbon footprint by using reused materials together with a timber structure, showing the large impact of using reused materials. The interviewees agrees that reuse will be important to reach future environmental goals in larger construction projects, showing the future demand for these materials. The most efficient way to lower the climate impact is to replace the materials with the highest climate impact to a reused product instead. Concrete and steel are products with high carbon emissions. Interviewee S4 mentions the great environmental benefit of using reused steel components because they have 95 percent lower carbon emissions compared to new steel beams while keeping its technical qualities.

In a project mentioned by C1, the foundation of the prior building was reused in a new construction project on the same plot. Interviewee CO1 also mentions a project where they are reusing hollow core slabs and glulam beams for the structure showing a great reduction of carbon emissions. Textile floor mats, suspended ceiling tiles and steel doors are also easy to reuse and have a large climate impact, making them highly demanded. According to S2, they also have a large demand of insulation and boards in wood and minerite.

Looking at excessive/saved materials, reinforcing mesh is appropriate to reuse since it keeps its technical qualities even after being stored outdoor according to S2. Whether this material category can contribute to environmental savings in the project depends on the client and the project, but according to S2, the provider of the excessive/saved

materials can include it as a reduction of waste and thereby lower the climate impact in their projects. C4 agrees with this, and their project have a goal to divert waste to lower the environmental impact from waste as they have a demand from the climate declaration of the amount of waste per square meter, therefore it is crucial to find alternative flows for the excessive/saved materials and the temporary materials.

5.2.1.2 Cost savings

The interview findings shows that there is a demand for reused materials for private people or small local businesses if the materials are noticeable cheaper than new materials while larger construction companies and real estate companies are willing to pay the same costs as for new materials if it results in a reduced climate impact for the project. Kvarteret Återbruket is another project by Framtiden Byggutveckling where the goals are to have 50 percent reused materials. The main goal in the project is to investigate which materials can be reused to minimize the costs and deliver housing with reasonable rents, even with a low carbon footprint. For reconstruction and renovation projects, reuse of material is more common and simple. According to consultant CO1, reuse of materials can be a win-win situation where reuse facilitates for cheaper, resource efficient and climate positive construction. Today, handling of reused materials is not efficient, and it is time consuming for the project. CO1 states that if suppliers of construction materials would offer reused products as well, the design stage will be less complex which would facilitate for the construction projects to use more reused materials. According to C2, there needs to be a viable business model for using reused materials in projects and the total project costs cannot exceed the cost of constructing a building with only new materials, which is something site manager C1 agrees with, referring to one of their projects where they were able to reuse the concrete foundation which contributed to a large cost saving together with a large reduction of carbon emissions.

Both CO1 and D1 agrees that smaller volumes of materials and components such as toilets are easy to sell for private people while larger constructions need volumes for it to be cost efficient. D1 mentions that it is common to reuse materials within the property stock to save money and reduce environmental impact while larger new construction projects face greater logistical challenges when it comes to material reuse.

It is important for suppliers of reused materials to have a large turnover on their storage. To ensure this, S2 have a low selling price: "*We have a very low selling price, about 20% of market value, which means that we can have a large rotation in the warehouse and be able to circulate such quantities*" S1 on the other hand manage to sell reused timber for about 80 percent of market value, but still, this is attractive for private people and small construction firms to lower their costs. S1 states that it is more difficult for large construction projects to lower their costs by using reused timber.

"The problem with larger construction firms is that they cannot buy 7 or 4 plywood boards, they want to buy a full pallet with plywood or studs. There need to be larger volumes for them to be interested. It cannot be too complicated and it's still rather complicated"- S1

This complicated process is costly for these actors; therefore, it is rather uncommon for larger construction projects to use reused construction materials such as boards and studs. On the other hand, S1 mentions that there is a high demand for reused doors to be used as temporary doors on construction sites, for the customer, these doors are cheaper than new and contributes to lower climate impact. S2 also mentions that they sell a small amount of construction materials and steel doors for temporary constructions.

In conclusion, a driver for buying reused materials is its lower price than new materials. Typically, private people and smaller businesses buy reused materials due to lower costs while it is cheaper for larger construction companies to buy larger pallets of new materials since the logistics of finding the right volumes of reused materials is too complicated. Larger construction companies also have better discount offers for new materials according to S3, making it less profitable to use reused materials.

5.2.1.3 Logistical aspect

During the interviews the logistical aspects have been discussed multiple times and different key opinions have been raised by several interviewees. One thing mentioned by both contractors and consulting managers is that storing the materials on site is a key aspect that must be taken into consideration. Today the sector is not mature and ready for reused material as explained by CO1 who said:

"In the construction industry time means money and to be able to do something quickly you need just in time deliveries, reuse is catastrophic when it comes to just in time deliveries and then you need to have your own storing and storing cost money and then you need to know how much storing is needed? When do I need it? How long do I need it for?" – CO1

This view is also shared by the contractors who mentions storing as a key logistical aspect regarding reuse. Contractor C1 develops the reasoning to mention different materials and said the following about the storing of them.

"*Materials like suspended ceiling tiles which are not resistant to mould needs to be stored dry with preferably some heat, then the winning of using those materials become quite small when you need to store them for such a long time*." *– C1*

Other materials are easier to store and handle according to C1 *"The steel products were taken to the blacksmith, and these materials can be stored outside for several years with no protection*." This shows the large variation that exists between different materials.

In general, storing of material is a costly measure that needs to be evaluated for each material and time period. Most materials can be stored, however, it depends on how much the client is willing to pay, which is often determined by the material's value and the required storage duration. When storage costs exceed the material's value, storing is no longer considered feasible. CO1 mentions one example of this when they needed to store windows for one and a half year which resulted in major costs and risks for the stored material.

When discussing logistical aspects of the demand of reused products it is clear from the interviews that any extra work or customization needed to accommodate for the reused products should be avoided. Some materials are better suited for this than others. CO1 discusses components like doors and windows that often are quite complicated to reuse. Doors especially needs to have a magnitude of technical requirements such as fire, safety and accessibility. Today, many doors include complex technical systems that must be compatible with the existing building or project. According to CO1, this is often challenging and typically requires the involvement of multiple consultants, which increases costs. This was also highlighted as a major challenge in the contractor interviews regarding the use of reused materials. C1 mentioned that they are unwilling to spend time sorting and analysing a pallet of, for example, gypsum boards. They added that if reused materials were delivered through the same channels and with the same integrated logistics as new materials, it would be much easier to manage.

5.2.1.4 Regulations and certifications

As mentioned in the theoretical framework there are no regulations or demands for incorporating reused materials in buildings today, there are however multiple regulations and demands that instead hinder the implementation of reused materials which have been evident in several of the interviews. The main one is the lack of flexibility in the building permits which often leads to extra work. CO1 solved this by procuring materials before the building permit was set. "*We found the windows first, dismantled them, stored them in a container for one and a half years and the architects could draw the facade based on those windows*." The normal way of doing it has always been to make all the drawings and permits first and then build everything while trying to make as little changes as possible. The workflows and regulations are in no way adjusted for reuse which is exemplified by CO1 saying that whenever you need to make changes to incorporate a reused material many specialists and consultants needs to be contacted to make sure everything is accounted for and that every technical regulation regarding fire, safety, access etc is fulfilled. Something that often complicates material reuse. As mentioned earlier, doors are a good example of components that must meet

multiple requirements, making them difficult to reuse according to CO1. The new BBR requirements were also mentioned by CO1 as they may drive demand for reused products, because they are more flexible and focus on the functionality of a product or material rather than specific characteristics.

In addition to this, the traceability and documentation is often something that complicates the reuse process. Since the origin of the product and detailed information often is missing it is hard to fulfil requirements regarding documentation, something that is often strict, especially in municipalities and other public organisations. C1 mentioned their project named "Hoppet 2". In the project they needed to use "Byggvarubedömningen" for all the building materials as a requirement from Gothenburg Municipality. This program allowed them to indicate whether materials were reused and did not require full product data, only the information that was available needed to be reported. More initiatives like this are needed to further promote and support the use of reused materials.

Warranties and quality assurance

The perception that warranties must be provided on all reused products is something that have been discussed in the interviews and the collective opinion is that providing warranties is not a key factor when it comes to demand of reused products. Several contractors mentioned that clients need to take responsibility for warranties. However, they often find warranties unnecessary for reused products, as warranty concerns are generally minimal for such materials. The contractors also mention the cost of warranties as a possible cause where C2 says "*I've been on the client side and the question is often if it is worth to pay for the warranty and since it often doesn't happen anything with the materials it is more worth to take it when and if it appears*". CO1 says the contractors do not leave any warranties on the reused material but instead on the work and handling of the material as usual. CO3 also mentions that they've given warranties on the function of the materials when selling inventories, which can work with some materials. The conclusion is that warranties is not a key factor since there are very little warranty claims on new building materials and that the clients understand that it is not feasible to demand it from the supplier or contractor.

There are however a few materials where warranties and especially quality assurance can be of importance from both a client and safety perspective. These materials are the structural elements. CO1 works with a project where the concrete hollow core slabs are being reused. These slabs have been sent to RISE testing facility to be tested for structural integrity. The steel beams they have bought have been sent to Stena Stål for quality testing and glulam beams have been sent to Moelven. Here it is clear that the demand for warranty and quality assurance on structural components is high and could be a potential selling point for a supplier of reused material.

Working environment and toxic materials

A new realisation from the interviews that was not addressed before is the impact that the working environment has on the demand for different reused products. For example, S2 explains that several years ago the builders could work with gypsum boards with a width of 1200mm but today there are rules for how heavy and bulky components are allowed to be which becomes a problem if you want to reuse old gypsum boards. Another example of this was explained by C3 who used tiles that were "saved" in their construction project. These tiles were second sorted which meant that they had less exact tolerances. This resulted in the tiler needed to put extra effort and time to get a good result. The working environment is an important aspect to think about and often result in that the materials that are the most similar to newly produced are the easiest to work with.

Toxic materials and substances are also something that is very important when discussing reused materials. A lot of older materials may contain some sort of toxic substances that might be forbidden to use. It is therefore important to have good knowledge on which materials this might concern. Contractor C1 talks about the importance of being able to provide information on every material to ensure the client that nothing that might be toxic are built in. This could be an incentive for suppliers since the demand for reused products where all information is available will be higher than for material with no known origin or table of contents.

5.2.1.5 Visual aspects

From the interviews another parameter has been added to the demand aspect. For new construction projects, the visual aspects in projects have a high impact when implementing reused materials. In new construction projects with high architectonic value, the architects are not always willing to compromise with their vision. According to C4, this have been a challenge in their projects since reused materials does not have the same visual standards as new materials. C2 also mentions that materials that is not so visual for tenants such as radiators, cable ladder and doors to rooms with lower requirements on acoustics can be changed to reused instead of new without impacting the aesthetics. CO2 mentions that they cannot compromise with the end results because tenants want the same standard as new materials.

> *"It should look the same as if it's new … we're not going to compromise on anything when it comes to load requirements, fire safety, or anything like that, it has to be like new. If we can't find it, then we'll buy new instead... Because in the end, it's a tenant paying a lot of money to be in these premises". -CO2*

But it seems to be challenging for new large construction projects to reach the final results:

> *"A tenants fit-out is fairly easy I'd say. But if you think of a big project, then we're just getting started because it's quantities of everything. We're not*

interested in single doors or single items of anything. If we're going to do something, it has to be at least a whole floor of the same thing."-CO2

The visual quality should not be compromised when reused materials are used, as tenants today are generally unwilling to pay the same price for facilities that appear to have lower standards due to the use of such materials.

5.2.2 Supply aspects

From all the interviews one common answer is that suppliers are going to play an important role when it comes to supplying reused building materials. However, no interviewee knows how the supply chain of reused materials will look in the future and the problem of supplying reused materials is complex and needs to be tried many times before finding the optimal way. The suppliers that exist today in the reuse market often have a broad selection of materials. All three suppliers S1-S3 have not chosen any specific products but instead focuses on gathering a magnitude of different materials and products to be able to cover for many different demands from the clients. This makes it hard for the suppliers to have any form of systematic reuse and often results in very project specific acquisitions depending on what the client wants.

Supplier S1 points out the fact that to be able to offer a good reuse product and system it is important to start on a small-scale rather than not starting at all. The learning curve in the beginning is steep and by starting small, the errors and mistakes that occur early can easily be fixed and revised, therefore costing less money than doing it full-scale from the start. Most of the suppliers today are yet to find their role in the reuse market and need to try what works and not. The suppliers that have a developed system for reused materials, for example S4 have been able to do so by focusing on highly specific products that are generic which is steel beams. By having a specific business model, they have been able to incorporate their reused product alongside their original products which makes it easier for them as a supplier but also for the customers, since they do not have to search for reused materials on different platforms. A key step in this process is being able to quality test the reused steel beam to able to classify it according to standards that exist. S4 said this about their reused steel beams.

"We have tried to change as little as possible in our processes to incorporate reuse and that it is the acquisition that is different. Later when it is quality tested, we handle it in the same way as a new beam, it goes through the same selling processes."-S4

This highlights how some suppliers, particularly those focused on specific products, have advanced further in their reuse processes and are able to operate in a more systematic manner than others. To only focus on a few specific materials or products could be a key factor when a supplier wants to enter the reuse market.

5.2.2.1 Procurement of materials

An important factor highly affecting the supply pattern is the procurement of materials. There are different ways for companies to gather materials, for construction materials such as boards and studs, most of the materials come from construction sites, where they gather reused materials that have been used in temporary constructions or excessive/saved materials being left over on site or sorted out from suppliers such as sawmills. Materials can also be gathered from demolition companies, internal networks and property owners from buildings undergoing renovation or demolition. IC2 highlights the logistical challenges in sourcing enough matching reused materials for large projects, which is confirmed by C2 who hired a reuse-contractor for finding larger volumes of reused materials for their reuse project. The procurement of materials is crucial to investigate when discussing the practicality of reuse.

Excessive/saved materials

Lots of excessive/saved materials are collected from construction sites where suppliers offer to come to construction sites and pick up used and leftover material which they see potential in reselling. S1 are providing this service, and the materials need to be placed on a pallet so it can easily be picked up by their transporters. But S1 are clear to point that they do not pick up waste:

> *"And now with the de-establishment work we're doing and the fact that we're taking back saved materials, everyone thinks that's great. Like, 'Oh, great, so you'll handle all our waste?' No, we won't handle your waste. We can only take care of the materials we're able to sell."-S1*

Since S2 operates logistic centres for their customers, they gather lots of their excessive materials from leftover materials at the centres. S3 on the other hand, receive most of their material from suppliers as for example sawmills who want to get rid of their off-grade materials, but they could also receive more materials from construction sites.

> *"We get a lot of surplus timber from the construction industry. We could also receive a lot more steel studs, there's a huge potential supply from construction companies but they're very hard to sell. Private individuals don't work with steel studs; they work with wood … they're typically used in larger construction projects. So that's a bit of a challenge. But right now, we have a project that's requesting them, a larger build so hopefully that can help create a market for it. The key is getting the construction companies to be willing to put in a bit more effort."-S3*

In conclusion, excessive materials can be gathered from de-establishment of construction sites or through logistic centres where materials cannot be returned to the construction material supplier or from off-grade materials from sawmills and other manufacturers of materials.

Dismantled materials

Dismantled materials refer to materials that have been dismantled from a prior building or construction. These materials are commonly collected from property owners through demolition companies or through reuse hubs. Dismantled materials can also be collected from suppliers of specific reused materials or through internal networks within municipalities or companies. C2 mentions that they normally find their reused materials through internal investigations within specific projects or through the client's own property stock. In larger projects they say that larger volumes cannot be found through internal communications, therefore they've hired a reuse-contractor:

> "*To scale this up and find, say, hundreds of doors that we need we can't just rely on communication and hoping to come across them. So, we're working with a reuse contractor. Not a consultant, but a contractor whose role is to help us scale up and source these products. Their job is to stay in contact with various demolition companies, which is part of their business model. And that's how we're able to access this kind of volume of doors and other products needed."- C2*

While C2 is using a reuse-contractor to gather material to their project C4 gathers their materials through specific suppliers of reused materials, for example they gathered all their façade material from a supplier of reused brick, and their steel from a supplier of reused steel. They also require their subcontractors to source reused materials for ventilation and electrical installations which was also done by C3 who found most of their product themselves but also had a close relationship with their subcontractors who also helped finding reused materials for their parts.

Suppliers of specific reused materials such as Bruksspecialisten, selling reused brick, Tarkett, selling reused textile carpets and Ecophon, selling reused suspended ceiling tiles have been mentioned by interviewees but they have not been interviewed as suppliers in this study. According to CO1, these suppliers often collect their materials from demolition projects, handle them and then sell as reused.

> *"Ecophon accepts old ceiling tiles that are theirs. And there are a few suppliers who have really gone public with this saying 'we accept our old products.' Tarkett, for example, has made a big deal out of actively searching for demolition projects with their flooring"* - COI

CO1 underscores the advantage for them to work with reused materials when suppliers are reselling their own materials and thereby complementing their new assortment with a reused assortment.

C1 found their reused materials from an internal storage with materials from demolition of projects with the same client, and the materials used were the same as they had available at their storage. S4 also handle reused materials and gather them through cooperations with a recycling company who work as a waste handler in demolition projects. In these cases, they can buy the materials from them and sell as reused steel, but they highlight the difficulties of working in this flow instead of handling steel from temporary constructions. S2 is another supplier of reused materials who also acts as a waste handling company, making them able to sort out materials in good condition and resell them as reused materials, but they also point out the difficulties with that specific workflow. S2 also have cooperations with demolition firms to gather their materials.

Interviewee D1 works with dismantling materials for reuse purposes. According to D1, all materials from offices are rather easy to dismantle and reuse. They also see potential in dismantling and reusing construction materials within the same project but underscores economic challenges in reusing materials such as gypsum boards in other projects.

Materials from temporary constructions

Lots of suppliers of reused materials gather their materials from temporary constructions since this material often keeps it qualities. S4 also states that most of their reused steel comes from temporary constructions and from temporary site facilities setups since these elements are only a few years old. S1 also gather most of their timber from temporary constructions on construction sites. S3 have also gathered masonite that had been used as floor covering from a construction site to resell it as a reused material. Masonite is commonly used for floor coverings, and are mostly in good condition after usage, so if construction companies would place them on a pallet, it can easily be gathered by suppliers and resold as reused for another project according to S3.

5.2.2.2 Logistical aspect

The supply chain of reused material starts with the procuring of material as described above. It is common that materials need some kind of handling, testing and storing before it can be resold. The following section highlights the logistical aspects from a supplying perspective.

Handling and testing

The problem with the procured material is often that it needs to be processed or refined in some way for it to be attractive for the buyer. This is often something that comes in the way for a supplier that wants to implement reused material. Supplier S1 says the following about handling of materials *"We basically only have a flat trading organisation; we buy and sell material that's what we do so we have very little opportunities to handle materials in different ways"*. They have solved this by only procuring materials that demand little to no handling or upcycling. They have gotten

good indicators from using wood and especially wood in temporary constructions, this type of material is easily sold and highly demanded by private persons and smaller businesses. These materials are also beneficial for S1 since they don't need to handle the temporary material to any major extent more than occasionally remove nails and screws. While S1 works occasionally with removing nails and screws, supplier S2 and S3 says that this is not economically beneficial for them to handle different lengths and to remove nails and screws. Plasterboards are also mentioned by interviewees as a material which are complicated and expensive to handle.

> *"But plasterboards for example, those are hopeless to handle. Although it is always possible but if it gets wet it gets destroyed, if the edges get chipped it gets destroyed and so on."- S1.*

But other suppliers do deal with plasterboards, for example S2 that has a lot of reused plasterboards. This shows the different mindset different suppliers have for different materials and that the processes are very specific for each supplier and material. IC2 says that if Derome were to deal with reused products they need to be standardised and with minimal handling and refinement to be used in their industrial processes. If it is possible to supply temporary materials this demands less requirements on the material making it easier to handle.

When it comes to testing materials, this is mainly of importance when discussing heavy and structural materials that needs to be classified. Stena Stål does this in their own process with reused products. S4 explains that they do this by destructive testing where the reused steel beams are classified in the standard strength classes. The materials in need for these types of testing would therefore need more handling and therefore cost more money. There are also other materials that might seem okay and that just needs an ocular inspection to be deemed okay to reuse but this could sometimes be false. Windows is an example of this where the function of the window might seem okay at first look, however windows often contain a gas in the void between the panel of glass to lower the thermal conductivity through the glass. According to IC2 this gas often leaks, and the technical qualities therefore decrease, these types of problem that is not visible to the naked eye are often difficult and costly to investigate and repair. However, it might be worth considering strength and quality testing since these materials often have more value built in the components and could be easier to supply as reused. This is something that have been mentioned by several of the interviewees that materials and components with higher value are easier to supply because of the high demand for those materials and products.

Packaging and transportation

Packaging and transportation are also vital parts to take care of for a supplier of reused materials. The collective opinion from a majority of the interviewees is that transportation is possible for almost all types of materials, but the packaging and type

of transport might differ and be easier for some materials. IC1 talks about the efficiency of transports and the filling rate of the trucks. The most important part for efficient and easy transports are the ability to fill the trucks as much as possible. There are of course materials better suited for this that have dimensions that are easily organised. IC1 also mentions the value of the products as a factor for how long transports can be, the more value of the products the longer the transports can be without losing profitability.

Another key aspect when talking about packaging is the length of materials. For example, wooden studs are very complicated to package and transport if they are separate length. S2 also mentions reinforcement as complicated to transport due to its length and dimensions. S2 also talked about the most practical materials to package and transport and here the opinion was clear in that stone is the most practical material since it doesn't need any packaging, and it is easy to transport a large amount in one transport where you can fit about 40 tonnes on one truck which amount to big environmental savings as well.

5.2.2.3 Regulations and certifications

The waste regulation is affecting suppliers of reused materials since the law governs who are allowed to handle waste. S1 highlights that they gather their materials from construction sites to avoid that it is classified as waste while S2 are a waste handler and thereby handle lots of waste and reclassify it as a product in their reuse process. S2 highlights that it is important to investigate hazardous waste, if any, to assure that they do not reuse these materials. An example of this was when they received mini fridges from an hotel.

> *"We were asked about, I think it was 800 mini-fridges, really nice ones, just two years old, from a big hotel in the city. And the demand was huge, like really high. But then it turned out they contained a refrigerant that wasn't environmentally friendly, and that just made the whole thing fall apart."- S2*

S2 explains that most hazardous waste originates from buildings constructed in the 1960s to 1980s. However, such materials are rarely encountered on today's construction sites, as their use is no longer permitted.

Another common discussion when it comes to reused materials is the warranties. As described in section *5.2.1.4 Regulations and certifications* it is today hard to give warranties on reused materials, and the demand for it have decreased. S1 says that they cannot provide warranties because they don't have any knowledge about the prior usage and handling of the product. Other interviewees agrees and the warranty question is no longer a problem for suppliers, unless the product will be used in load bearing constructions. In these cases, the materials need to be controlled and tested to assure the right quality. S4 mentions that for steel, there is an industry standard for how to quality-assure structural steel, which makes them able to sell reused steel with the same guarantees and documentation as new steel.

> "*The key reason we're able to do this is that there's now an industry standard for how to quality-assure reused steel for load-bearing structures to meet the EN 1090 requirements. That's really the only reason it's even possible. Without that, reuse would be limited to things like bike racks, and then you lose the whole point of it. That standard is what makes reused structural steel viable and profitable." – S4.*

As described in webinar "*Nye norske standarder for returtre*" by Circular Bioeconomy Arena, the Norwegian standardization association have together with Norwegian institute of wood technology made a national standard for quality assurance of structural elements in reused timber. This is showing the potential for increased use of reused timber for structural elements like steel in the future due to rules on how to assure the quality of the material. The quality testing is in general costly but necessary for actors such as S4, while it is too costly for the other suppliers interviewed in this study. According to IC2 there is a system called Dynagrade used for timber strength grading, sending a pulse through the timber and measuring its strength which they use for new timber. Whether this system could be used for strength grading of reused timber is interesting to investigate further, as a way of quality assure reused timber.

5.2.3 Evaluation of the material groups and their practicality for reuse

The material categories and subcategories are evaluated in *Table 5:2* based on the theoretical framework regarding demand and supply and the results obtained throughout the study. To clarify the results the table are coloured in green, red and orange to present the overall practicality for material reuse. The evaluation of the practicality for supplying the materials are based on if a construction material supplier like Derome were to supply the materials.

Table 5:2 Evaluation of materials and their practicality for reuse based on the theoretical framework.

Material category	Demand	Supply
Paving materials *Paving stones* *Curb stones*	**Environmental:** Moderate, often not accounted for in a building project, reuse reduces need for raw material extraction. **Cost savings:** High potential cost savings. **Logistics:** Can be heavy and bulky to handle. **Regulations and certifications:** No mentioned problems.	**Procurement of materials:** Easily available from constructions or demolition sites. **Logistics:** Heavy transports but easy to load full trucks and thereby maximize transport. **Regulations and certifications:** No mentioned problems.
Wall and roof cladding *Bricks* *Slates* *Roof tiles*	**E:** High, bricks and tiles have long lifespans, reuse helps reduce CO_2 emissions. **C:** Same or less cost than new materials. **L:** Risk of damage; requires careful handling, often visual differences. **R:** Uncertainty about old materials, may contain hazardous substances.	**P:** Moderate, manual deconstruction needed for intact pieces. **L:** There are suppliers specialized in reused bricks. Storing and transportation easy. **R:** Uncertainty about old materials, may contain hazardous substances.
Constructions of ready to assemble elements *Joist* *Hollow core slabs* *Glulam beams* *Concrete foundation*	**E:** Very high, large embodied carbon savings if reused. **C:** More logistical costs and extra time in the design stage but the materials are often cheap. **L:** Challenging, often heavy and require disassembling. **R:** High barrier, structural safety standards must be met.	**P:** Complex, full documentation often required. **L:** High complexity and cost. **R:** Difficult, requires testing and quality assurance to meet the requirements.
Material sold per length unit wood *Studs*	**E:** Rather low for wood materials. **C:** Often lower price than new materials. High demand for private actors and smaller firms. **L:** Could be variations in quality. **R:** Needs certification for structural use.	**P:** Common in demolition projects. **L:** Manageable if categorized early. Must be cleaned from screws and nails which is time consuming. **R:** Grading required for structural use, visual grading or stress testing.
Material sold per length unit steel *Structural beams* *Studs*	**E:** High, extends lifecycle of high-energy materials, 95 percent lower kg CO_2eq for a structural steel beam. **C:** Same price as new materials. **L:** Could vary in dimensions which must be considered in the design stage. **R:** Needs certification for structural use.	**P:** Common in demolition projects, careful dismantling. **L:** Testing/sorting and measuring of the materials needs to be done. Could be hard to find end customers for steel studs. Structural beams are demanded. **R:** Quality testing and grading required for structural use.
Boards in different materials *Plywood* *OSB* *Gypsum* *MDF*	**E:** Moderate, reuse reduces landfill and manufacturing. **C:** Low to moderate. High demand from smaller firms and private actors or within the same project. **L:** Lightweight but often damaged. **R:** Minimal impact.	**P:** Moderate, often damaged in removal. **L:** Lots of handling costs with cleaning it from nails and screws. **R:** Usually not regulated.

Complete components *Doors* *Windows* *Kitchen*	**E:** Moderate, extends life, avoids waste. **C:** High cost savings if condition is good. **L:** Medium complexity; needs matching sizes/styles and in some cases refurbishment of inner doors. **R:** Windows may have energy standards and doors might have accessibility requirements, fire and noise requirements.	**P:** Rather easy to dismantle. **L:** Fragile, careful storage needed. **R:** Windows may have energy standards, and the U-value of a window can be affected after long time, testing might be needed.
Furnishing and trim *WC/sink* *Suspended ceiling tiles* *Textile carpet*	**E:** High for suspended ceiling tiles and textile carpets. **C**: High. **L:** Relatively easy. **R:** Acoustic demands can require thicker ceiling tiles. Can be solved by placing two on each.	**P:** Common during interior deconstruction. Easy to dismantle. **L:** Simple; compact and reusable. Ceiling tiles need storage in heated spaces. WC/sink needs cleaning but keeps its qualities. **R:** Quality assurance might be expected. Provided by Ecophon today.
Insulation *Stone wool* *Glass wool* *PIR* *Cellular plastic*	**E:** High potential but rare in practice due to contamination concerns. **C:** Low due to testing/removal costs. **L:** Bulky, may be contaminated or degraded. Some examples where cellular plastics have been reused successfully. **R:** Uncertainty about old materials, may contain hazardous substances	**P:** Low, often not viable due to age and contamination. **L:** Complex, removal and safe storage needed. **R:** Uncertainty about old materials, may contain hazardous substances
Technical installations *Cable ladders* *Radiators* *Ventilation ducts* *Luminaries*	**E:** High environmental savings. **C:** Potential cost savings. **L:** Complicated installation due to modifications for ventilation ducts. Cable ladders are easy to handle. **R:** Quality assurances are often needed for technical installations.	**P:** Rather easy to dismantle. **L:** Cleaning of ventilation ducts. Cable ladders are easy to supply. **R:** Warranties/quality assurance for technical systems.
Temporary material *Steel beams* *White goods* *Timber for castings* *Masonite* *Doors, studs etc, for construction sites*	**E:** High, for materials with high CO_2 (steel, white goods etc), and for materials with long technical lifespan left. **C:** Often less expensive than new materials but in good condition. **L:** Easy to manage, often in good condition. **R:** Often have documentation since they're rather new.	**P:** Available from finished projects. **L:** Easy, often modular. **R:** Documentation available.
Excessive/Saved materials *Boards* *Studs* *Insulation* *Tiles*	**E:** High, reuse prevents waste of new/unused material. **C:** High, brand new material at no production cost and lower selling price. **L:** Straightforward if labelled/stored. Can be bought in pallets. **R:** Usually meet product standards if unused.	**P:** Available on construction sites, or logistic facilities. **L:** Often in original packaging. **R:** Generally still certified as new.

As shown in the table, there is an imbalance in supply and demand for reused materials. Materials with high environmental impact are generally demanded by construction companies and real estate property owners to lower the environmental impact in projects while private persons choose reused materials if supplied at a lower cost than new materials. Materials with high environmental impact such as concrete elements and steel beams are although hard to supply due to logistical challenges and regulations affecting the supply.

Materials with low demand and difficult supply patterns are insulation and boards in different materials due to complicated handling and fragile materials, making reuse hard. Materials with favourable demand and supply patterns are paving materials, wall and roof cladding, furnishing and trim, temporary materials and excessive materials showing great potential for reuse. Understanding the potential and difficulties of reusing different materials are important to determine which materials are practical for a certain supplier to reuse.

5.3 What materials are most profitable to reuse?

The result of which materials are the most profitable will be divided into different parts for easier understanding and analysis. These parts will be of the same structure as the theoretical framework in Chapter *3.2 Profitability/Financial aspects.* The result start by explaining the result of analysing the market share. The market share of reused materials is primarily based on the qualitative data such as interviews and site visits since there are no quantitative data available on market share of reused materials because of the immatureness in the reuse market. The market share on new materials is instead based on quantitative data, both provided from Derome but also public data on building materials. These two components form the basis for the conclusion on which materials should be prioritized by a building materials supplier looking to enter the reuse market. Both market share parts do not separately provide the full overview but hopefully the two combined give a better understanding of the market share of reused products.

The market share is combined with the other part of the profitability section, which is the cost. The different costs associated with reused products is divided into the same parts as the theoretical framework with cost associated with *Procurement/Dismantling, Handling and Regulations.* The different cost is not estimated to real numbers since the data on the cost is too immature to get a reliable answer. Instead, a grading is made to show the difference in cost between the different materials. The cost and market share will then be presented in the table introduced in the theoretical framework: *3.2 Profitability/Financial aspects.*

5.3.1 Market share of reused materials

The market share of reused materials differs substantially, and it is difficult to provide a comprehensive analysis of the market today. The market share of different products differs depending on which person that talks about the subject, what project and what role or interests the person or company have. From the interviews the results are clear in that some types of material are more frequently reused and therefore have a higher market share. It is also evident that building material is less frequently reused than for example interior fittings, furnishings and complete components.

A good example of high market share reuse materials that have been mentioned by several of the interviewees is *textile carpets* and *suspended ceiling tiles*. These materials have a high turnover rate and both the demand and supply side are positive about reusing these materials and they have already a major share of the reuse market. Some other materials that today have a large market share is different types of furniture and fittings for repurposing of for example offices. These types of products are the most common when talking about reuse today since these can often be reused in the same building or between the internal organisation in a real estate company. These materials and products can be *lighting fixtures, glass walls, doors* in addition to the previously mentioned. This is because of the easy handling and that there are limited requirements on those types of products. There is also a high grade of standardised products that can be used in any office or public building.

When discussing specific building materials some of the materials have a higher market share and this often depends on who the end customer is. If it is a private customer the typical building materials often have a larger market share such as studs, boards, and on many occasions doors and windows. This is because it is easier for them to use these materials since they have time and possibility to modify them and often don't require the same standards. If the customer is a large construction company the reused material with the largest market share is often heavy large components that have a bigger climate savings or installations and products that can be found in large quantities with the same dimensions and/or specifications.

5.3.2 Market share of new materials

The markets share of new materials will be sourced from quantitative data provided by Derome. This data is categorised into different categories that does not match up entirely with the categories in this project, therefore the categories with most revenue will be displayed to show an overview of the market share today. The data is also divided into large construction companies, see *Figure 5:1* and smaller clients, see *Figure 5:2* to show the differences in the market share between these two groups of customers. The graphs do not represent the exact relation between all the material groups since there are many other materials that are not included and should therefore not be seen as an exact representation but merely an estimation to show what potential there might be for reused products of different materials.

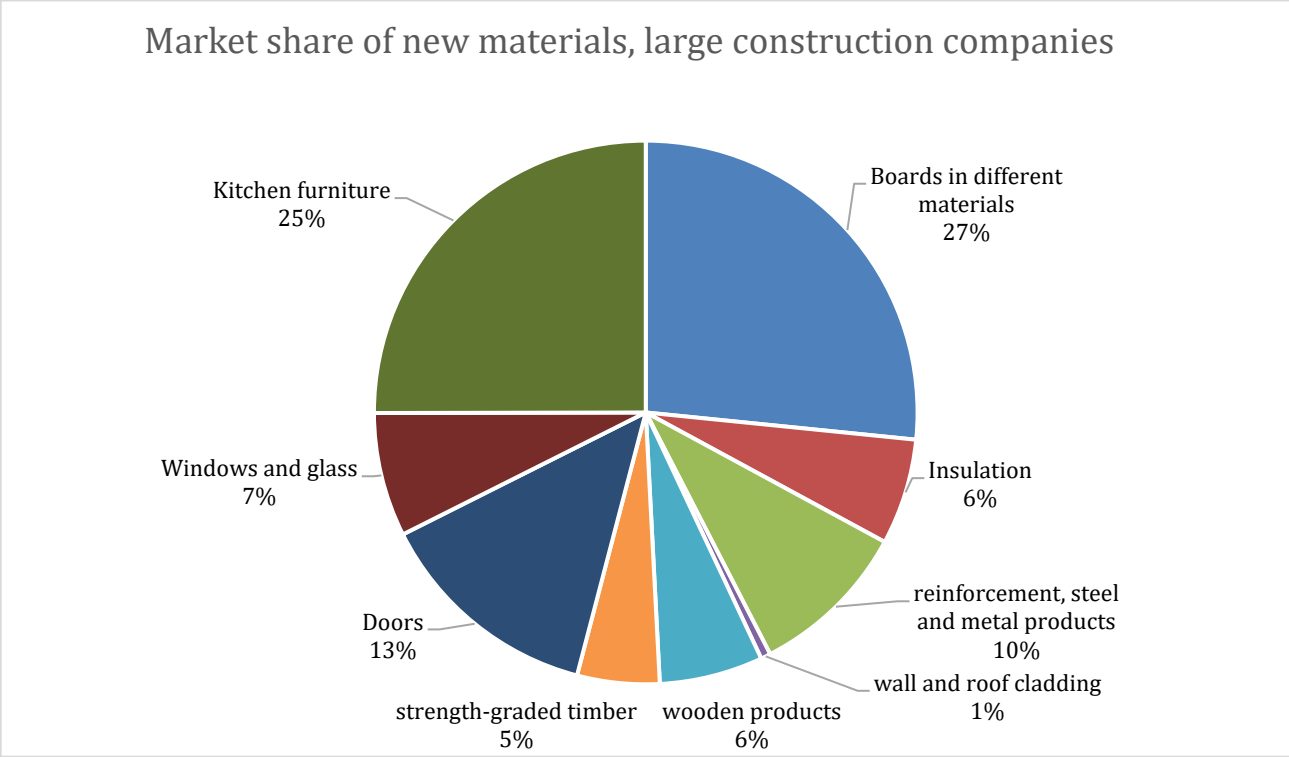

Figure 5:1 Pie chart describing the relation between the 9 categories with the most market share (revenue) among large construction companies.

In *Figure 5:1* we can clearly see some categories that are dominating the market share of new materials sold. Boards are a major part of the newly sold products, this involves all types of boards such as plywood, gypsum, MDF, etc. This could show that there are a lot of boards that are being used in large construction project and that there might be a high potential of both procuring boards for reuse purpose but also a high demand for reused boards of different sorts. The only example of reusing boards mentioned in the interviews is that in rare cases gypsum boards have been dismantled and reused although this is seen as very costly. Another dominating category that might be surprising is kitchen furniture. This category also stands for a major part and has been identified by some of the interviewees as high potential reuse products.

The other groups are relatively even distributed and show some groups that also have been discussed as potential reuse products. Doors and windows have together a substantial market share which often is explained by the high value of these products that results in a high market share. These are also products that are seen as having high reuse potential because of their high value. The smallest category is wall and roof cladding who don't have a substantial market share in relation to the others.

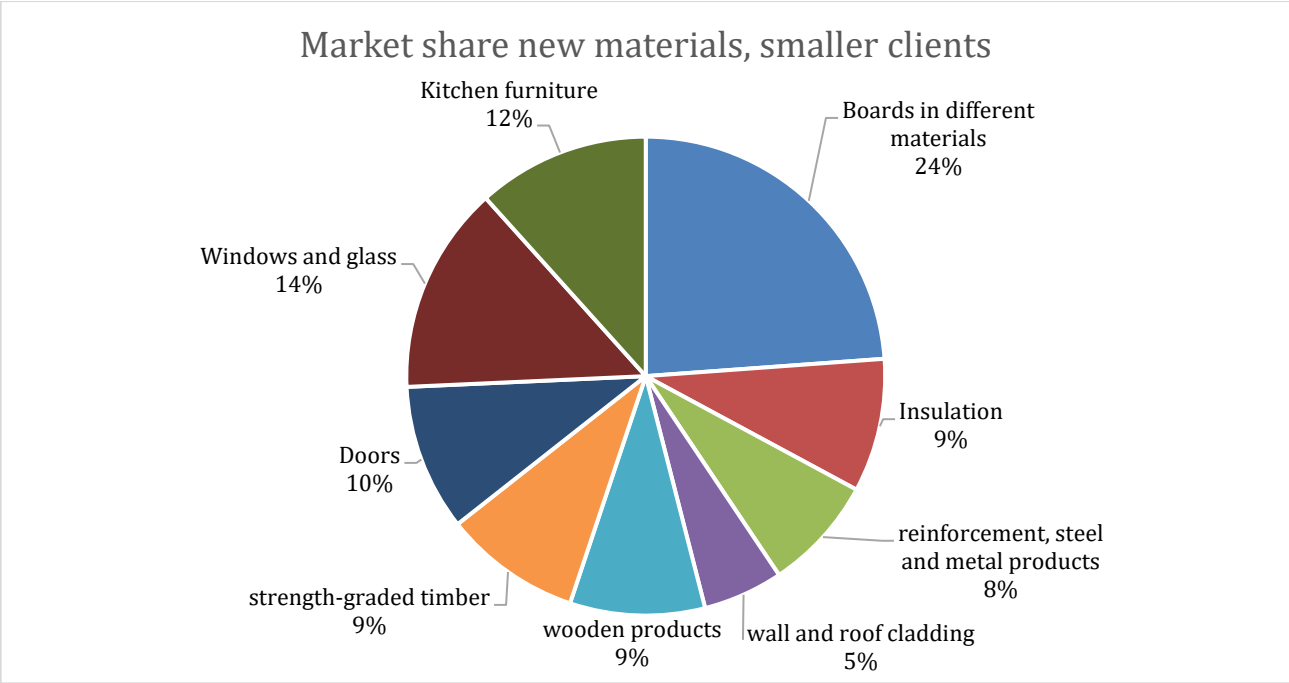

Figure 5:2 Pie chart describing the relation between the 9 categories with the most market share (revenue) among smaller clients.

When looking at the market share for smaller clients we can see some differences and similarities compared to large construction firms. Boards still have roughly the same market share while kitchen furniture have substantially lower market share. This could mean that the focus for reused kitchen furniture should be directed to larger firms. It is also clear that *strength-graded timber, wooden products* and *wall and roof cladding* form a larger share than for the larger clients. This could show that smaller clients buy more specific parts and smaller purchases to complement their projects. This could benefit a supplier by focusing on smaller clients for reused products such as timber studs, wall slates and other specific wood components. There is a clear demand for these products when they are new, and many smaller clients are willing to also buy these products reused if they could buy it at a lower price than new materials.

One important thing worth mentioning when discussing new and reused materials is the question of competing markets between the new and reused material. Could selling reused products affect the amount of newly sold products in a negative way? Although this might be a risk in the future, today reused materials and new materials are not competing about the same clients or products. The projects that need to have reused products are going to need it no matter what and are going to choose the supplier that can provide it. Therefore, it is important for suppliers to have some sort of circular offer which might benefit the company economically by attracting more clients.

5.3.3 Costs

Costs associated with supplying reused materials varies depending on the materials, how it's procured, whether the materials need handling and if there are any costs associated with regulations for using the materials again. Today, large part of the materials that are reused are used in internal property stocks and no third party are involved. The material categories will be evaluated based on the mentioned cost aspects to investigate what materials are less respectively more costly to reuse.

5.3.3.1 Procurement of materials

The procurement of reused materials varies depending on the actor and their role in a construction project. For project managers, representing the client, they often purchase the reused materials from digital marketplaces such as CC build, through initiatives within the client organisation, through reuse hubs or from suppliers of reused materials. They often buy the materials but at the same or lower price as new materials. All interviewees agrees that the total project cost cannot exceed the cost of using new materials.

Suppliers of reused and saved materials on the other hand, are often gathering their materials from demolition firms, construction companies or from material suppliers such as sawmills. Whether they pay for the materials varies depending on the company and the material quality. S3 mentions that they buy all their materials from suppliers or construction companies but the price for them to purchase the materials are low.

> *"We basically always pay for the material we bring in. Sometimes we get it for free if it's in too poor condition … often as a construction company, it costs money to throw it in a container and transport it away. If you can get back maybe 10–20% of the purchase price, that's better than paying 10–20% to throw it away"- S3*

On the other hand, S1 are mainly gathering all their materials for free. They are paying for excessive materials if they receive materials in good quality that they know they could earn lots of money on, for example if the customer ordered wrong and it's a high value of the material and cannot be returned to the supplier. For S2, who are a waste handling company and logistics firm, they invoice the customer for gathering materials since the materials are classified as waste compared to S1 and S3 who only handle products and not waste. S4 on the other hand handle steel which are regulated by scrap prices, so they always pay for scrap. According to S4, they pay an extra Swedish crown for old steel beams without documentation and two Swedish crowns extra for steel beams from temporary constructions where the beams have all necessary documentation when they are suitable for reuse.

None of the suppliers interviewed in this study are dismantling their materials, according to S1 they don't have the resources for dismantling materials and are thereby using external partners for this. The dismantling firm D1 are on the other hand are dismantling materials and selling them as reused through a reuse hub, owned by a real estate company. They get paid from property owners for dismantling the materials, but it's not allowed to cost more than a new product. The property owners are then using the materials in their other properties, in other parts of the same building or selling them through their reuse hub. The price for dismantling materials is according to D1 lower for a dismantling firm than for a carpenter and they underscore the advantage for them to offer the whole service chain from inventory to dismantling the materials and thereby they can offer a reasonable price for reused materials.

It can be assumed that materials that are complicated to dismantle are the most expensive materials to procure. According to D1, gypsum boards are not profitable to dismantle: *"Purely economically, it's completely worthless to deal with gypsum boards … we sometimes do it if it can be used in the same facility"* While textile carpets and suspended ceiling tiles are easy to dismantle. They also mention that laminated glass is easy to dismantle although it needs some handling before being available for selling.

5.3.3.2 Handling/logistics

The handling costs appears to be challenging when selling reused materials. Most of the materials being dismantled from a building need some kind of handling before it can be sold. D1 mentions that suspended ceiling tiles are easy to dismantle and pack, but according to C1 it needs to be stored in a heated space which could be costly if the projects need to store them for a longer time, but compared to other materials the ceiling tiles are cheap to handle. Textile carpets are cleaned before being dismantled which is also considered easy and cheap according to D1, but they need large volumes to make it profitable. Laminated glasses are also according to D1 easy to dismantle but it needs to be cleaned from silicone. CO1 also mentions that large glass sections are heavy and demands special handling which could be time consuming and expensive. For façade windows, IC2 highlights the uncertainty of the remaining energy performance of the products.

> *"I was up at RISE about three weeks ago and met a man, he works with windows. He's involved in a reuse project focused on windows, and he really knows his stuff. He said: 'We had some windows brought into the lab for analysis. I thought these were good windows—I would've said myself, this is a good window. But they couldn't be reused.' … They have a camera that can flash to check whether the gas inside the window is still intact which it wasn't". -IC2*

IC2 highlights that these windows could be used by private people but companies that have high energy demands need to be sure their materials fulfil the energy demand, and to test all windows in a machine like the one at RISE is not economically viable. When

reusing construction materials such as boards and studs, cleaning from nails and screws are the most expensive and very time consuming as well as sorting and drying the materials. Gypsum boards are more complex since they are fragile and sensitive to moisture, making them more expensive to handle and they should be used within the same facility according to D1, to minimize risks of damaging the material.

Another material mentioned by S3 is inner doors. These materials need handling which in some cases are not profitable for the supplier due to high handling costs compared to the value of the product.

> *"They want them to look brand new, so you basically have to repaint and re-lacquer every single one. And if you're going to re-lacquer an interior door or just a door leaf, which a construction company can buy for around 200–300 SEK, then the whole process; removing handles, sanding, filling, painting would have to be fully automated, and you'd need to process about 1,000 doors a day for it to make any sense. So, we've felt that it's not worth putting effort into it, considering how little material there actually are in an interior door". -S3*

A solution is according to S1 to sell the reused doors to construction sites for temporary use, where new doors have been used historically, thereby they don't need to refurbish the materials. D1 dismantles lots of doors for reuse purposes and says that because they have the infrastructure for handling doors, they can make it profitable:

> *"When we take down a door, we remove it, mix it in with others, and send it off for lacquering. It's not like we move it 14 times, first to storage, then to lacquer … Because we've done this so many times now, we know exactly what it costs to take down a door, what the storage handling costs are, and what the purchasing costs are. And of course, if we can send off 20 doors at once, it's obviously cheaper than sending off just two. So, the key thing here is really that there's a massive amount of logistics involved. We need to be time efficient, and the biggest time factor is transporting the material back and forth.". -D1*

IC1 also highlights the importance of understanding a product value compared to its handling costs and underscores the difficulties of reusing timber with lots of nails and screws because new timber is cheaper in comparison. S1 agrees that it's hard to make the process of selling reused timber profitable since there are high handling costs, but the demand is high, and they manage to sell the materials for 80 percent of full price showing the great potential to make it profitable over time.

The main purpose of using excessive or saved materials is that there are very low handling costs for it. Often it is easy to package, transport and resell, making it easy to handle and make profitable.

Storing of the materials is another logistical impact affecting the cost. A large turnover of the storage seems to be essential to make the business profitable. Materials that are easy to store and load on pallets are the best, and large bulky products should not be stored for longer times. S1, S2 and S3 all have a large turnover of their storage. And both S2 and S3 sells most of their materials within a month with some exceptions. It is especially important with short storage times for large bulky products since it is too costly to store them for longer time. The interviewees mention that most of the materials stored for longer periods are either small items that take up minimal space or materials already purchased by a project that is covering the storage costs.

Transportation costs are also important to consider. The transportation costs align with the practicality of transporting materials mentioned in *5.2.2.2 Logistical aspect*. The materials that are easy to package and load and with a high filling rate of the truck are also the most cost-efficient materials to handle.

5.3.3.3 Regulatory

Cost related to regulatory measures differs depending on what type of material it is, what the client demands and how extensive testing or quality assurance needed to be done. As discussed, if the client is a private person or smaller business the demand of the product is usually lower and therefore there are less regulatory costs associated with the material. However, if the client is a municipality or larger construction firm there are often higher demands on documentation and traceability which puts higher demands on the supplier which often result in higher costs associated with regulations.

Another important aspect of regulatory cost is associated with the structural materials. These materials often need rigorous quality testing and certification to make sure that they can be reused as structural elements with the same integrity as before. The cost of this testing and quality assurance can often amount to large numbers meaning that the profitability of the reused component decreases and, in many cases, makes it unprofitable to reuse. A key aspect when discussing the quality testing of materials is if there are any certificates available, this is often the case in temporary constructions. When having a certificate there is often no need for testing which makes it cheaper. If testing were necessary, an important aspect is the volume of material which often affects the profitability as explained by Supplier S4.

> *" If we have material certificates, then there is significantly less extra work. Then we basically just need to check that it meets the dimensional requirements. However, if it involves destructive testing, that process has a fixed cost. So, we need to bring in a certain volume to cover the cost per kilo, simply. If it's a control group of around two to three tons, then we can make it work and achieve a reasonable cost for the quality assurance. Otherwise, the beams become extremely expensive." –S4*

This is something brought up by several of the suppliers in the interviews, that if volumes are large enough it is easier to make the quality testing profitable for heavy structural elements.

5.3.4 Selling price

The selling price is an important aspect in profitability of reused materials but have not been the main focus of the profitability section. However, some observations and discussions have taken place during the interviews that are important for the aspect of profitability. First thing that is important to mention is that the selling price differs depending on who the customer is. Private clients or smaller businesses that don't value the environmental savings as much, want to buy the reused products at reduced price compared to new while larger companies are willing to pay the same price as new materials if it will contribute to an environmental saving for the project. From the interviews it is clear that most of the material sold to private actors are sold for less than the original price for new material. Supplier S1 says the following about pricing of their reused products:

> *"It depends, timber products we try to keep the price up around 20% below their regular price, sometimes it is even lower but we try to keep it up, even if we've gotten the material for free it is a lot of work with handling and so on, so it usually evens out to plus minus zero, the products themselves are not expensive, timber is not that expensive."-S1*

It is clear from this supplier that they try to keep the price up as much as they can on timber products but since the materials themselves are not worth a lot of money, they must be able to offer lower prices than the original to be able to attract customers such as private clients and smaller building firms. It is clear from supplier S1 that they do not make the reuse business profitable today, but they try to make it neutral in terms of profitability to be able to work out the optimal way of dealing with reuse and then try to make money from it.

Supplier S2 who works with waste and reclassification of material do not pay anything for the materials they receive. This creates an opportunity for a very low selling price and they sell their reused material for about 20 percent of the original price which is a lot less than for example S1. According to S2 this creates the opportunity to have a large rotation of material in their storages and by having a large inventory rotation they can create a net zero profitability organisation, just as supplier S1. Supplier S3 mainly sells excessive materials and only reused to some extent. Since they have much less handling of the excessive material they are willing to pay for the procurement of materials in contrast to the others. They are able to sell the material with about 50 percent discount of the original price for new materials. This business model works for them and generates profit for the company. From all the suppliers it is clear that to be

able to sell to private clients they need to lower the price. If larger construction companies and innovative projects want reused products they are often willing to buy the material for the same price as new granted that they can account for the environmental saving and if they can receive the right volumes.

Overall, the selling price varies depending on the supplier, their main material category, and their customer base. In general, larger suppliers for whom reuse is only a small part of their business aim to keep the reuse segment cost-neutral, while suppliers focused solely on excess and reused materials are able to generate profit from reuse.

5.3.5 Evaluation of the material groups and their profitability for reuse

To summarize the Cost and Market share of each material category a similar Table to the one presented in the practicality aspect was performed. *Table 5:3* aims to give an overview of the profitability aspects for each material. Since the market share differs substantially between new materials and reused materials the choice was made to include both market share to give a broader overview and to be able to compare these different market shares for each material category. The cost aspects are presented with a short comment on each cost category since the cost can differ quite substantially between the different categories. No colour coding was chosen on this table in contrast to the practicality because of uncertainty between new and reused market share as well as substantially different cost for each cost category which made it hard in many cases to put a single grade or colour on each material group.

Table 5:3 Evaluation of materials and their profitability for reuse based on the theoretical framework.

Material category	Cost	Market Share
Paving materials *Paving stones* *Curb stones*	**Procurement:** More time consuming than new materials but relatively easy process. **Handling/Logistics:** Heavy transports, and heavy materials to handle. About same handling cost as new materials. **Regulatory:** Small to no cost.	**Reused material:** Low market share, big potential for larger market share due to the easy handling and regulations. **New material:** Moderate use of new materials, varies depending on project.
Wall and roof cladding *Bricks* *Slates* *Roof tiles/sheet*	**P:** Gentle dismantling could be costly. **H/L:** Durable materials, needs cleaning and painting in some cases but relatively easy to handle. **R:** Visual aspect could impact the building permits and thereby regulatory cost.	**Reused:** Specific companies have large market shares such as "Bruksspecialisten". **New:** Moderate/Low use of new materials.
Constructions of ready to assemble elements *Joist* *Hollow core slabs* *Glulam beams* *Concrete foundation*	**P:** High costs associated with dismantling the materials. **H/L:** High storage and transportation cost. **R:** High costs associated with quality testing, documentation.	**Reused:** Small market share of reused because of complexity. **New:** Large volumes and weights used as new products.
Material sold per length unit wood *Studs*	**P:** Small cost to dismantle the material. **H/L:** High handling costs for cleaning the materials from screws and nails. **R:** Small to no cost.	**Reused:** Small market share of reused, potential depending on how to solve the logistics and handling. **New:** High market share of new material.
Material sold per length unit steel *Structural beams* *Studs*	**P:** Careful dismantling is expensive, but material prices are only a bit more expensive than normal scrap prices. **H/L:** High costs for testing. **R:** Often structural, high cost associated with testing and classification.	**Reused:** Moderate/High market share of reused for use in temporary constructions. **New:** High market share in complex projects with high structural loads.
Boards in different materials *Plywood* *OSB* *Gypsum* *MDF*	**P:** Gentle dismantling which could be costly. **H/L:** High handling costs of cleaning the materials from nails and screws. **R:** Small to no cost.	**Reused:** Low market share of reused, although examples have been successful. **New:** Very high market share of new material.

Complete components *Doors* *Windows* *Kitchen*	**P:** Easy dismantling. **H/L:** High handling costs for refurbishment and storing. **R:** Varying, sometimes high due to testing and documentation of doors and windows.	**Reused:** Moderate market share with high potential. Demand heavily controls the market share. **New:** High market share, these products are always used and has a high economic value built in.
Furnishing and trim *WC/sink* *Suspended ceiling tiles* *Textile carpet*	**P:** Easy dismantling. **H/L:** Low handling costs. **R: S**mall to no cost.	**Reused:** High market share, suspended ceiling tiles and textile carpets are reused in almost every project that implement reused products. **New:** Moderate/Low market share of new materials.
Insulation *Stone wool* *Glass wool* *PIR* *Cellular plastic*	**P:** Can be dismantled and reused. Easier for cellular plastic since it's not as sensitive. **H/L:** Testing required, drying, packaging. **R:** Sometimes testing and documentation of possible hazardous substances.	**Reused:** Low market share, with small potential for higher share. **New:** Moderate/High market share.
Technical installations *Cable ladders* *Radiators* *Ventilation ducts* *Luminaries*	**P:** Gentle dismantling of fragile installations. Cable ladders are easy to dismantle and reuse. **H/L:** Medium. Testing might be needed. Cleaning of ducts. **R:** Varying, documentation and certification of ducts, type of luminaries etc.	**Reused:** Low market share, interest and potential of making the share higher, need for better processes and documentation. **New:** Moderate/High market share of new material depending on what type of project.
Temporary material *Steel beams* *White goods* *Timber for castings* *Masonite* *Doors, studs etc, for construction sites*	**P:** Easy to procure, sometimes need careful dismantling which can be time consuming. **H/L:** Depends, most of the temporary materials don't need handling except timber for casting which have high handling costs. **R:** Small to no cost due to the lower requirements of material and components. Testing of structural elements might be required but all documentations are often available, making the tests less complex.	**Reused:** Moderate market share with very high potential. Steel beams from temporary constructions are common for reuse by Stena Stål. **New:** Still high market share of new material, this market share could almost completely be changed to reused material.
Excessive/Saved materials *Boards* *Studs* *Insulation* *Tiles*	**P:** Small costs, often available in packages or easy to package. **H/L:** Small. **R:** Small, sometimes documentation needed.	**Reused/New:** Specific companies dealing with excessive material that are winning larger market shares due to lower selling prices, mainly providing to private customers and smaller companies.

6 Discussion

In the following chapter the results presented in line with the theoretical framework will further be analysed and discussed. The discussion will start by presenting different drivers for reuse and what the consequences are of these. The chapter will follow the previous structure with a clear distinction between practicality and profitability of reuse. In addition to this, the same material groups will be used to continue the systematic approach with a clear categorisation of the different reused materials. The chapter will graphically present the different material groups and provide a suggestion on how to categorise them based on the result. In addition to this the research questions will be further complemented by insights and ideas that have been brought up several times during the process of this work. This will add knowledge and ideas that goes beyond the hard facts presented in the result and will give room for further discussions and research in the field of reusing building materials.

6.1 Drivers for material reuse

During the interviews and conversations regarding reuse of building materials, some main drivers have been identified for the reuse business in general which are important to discuss. First off, it is crucial to identify how a client or supplier defines reuse and what materials that can be regarded as reuse. The definition of reuse differs from different projects and clients due to the lack of a clear legal definition of the term reuse which is also confirmed by Sveriges Kommuner och Regioner (2023). Throughout the interviews, the concept of saved materials has been frequently mentioned where several actors do business by selling these materials that have been leftover on-site. We do believe that it is very important not to get caught in the specifics and definitions of reuse and instead see the excessive/saved material as a measure for minimizing the large amount of waste from construction sites and prolong the life of materials by incorporating a circular flow. These materials are often easy to handle and resell with minimal handling (Industrifakta, 2025). All measures made in the area could be defined as a circular concept or offer to include all types of materials and processes such as saved materials, excessive materials, second sorted materials, temporary materials etc. By doing this the fear of greenwashing and backlash due to uncertainty of the definitions will be dispelled. This should be made until a clear definition, and standard is provided from the relevant regulatory departments which is missing today.

The environmental aspect is also something that have been a returning subject throughout the work. The environmental savings have purposely not been analysed to provide exact data on how much climate savings each material category have. Instead, the overall concept of environmental savings has been discussed and has resulted in some valuable insights. It is evident that the construction sector is facing large fundamental changes to adjust for the big climate impact that the sector has. This will be done in all areas with different methods. What has been mentioned by almost everyone involved in this project is that reuse will not be the single biggest contribution

to this industry change, but it will be just as an important part as everything else. Everyone is convinced that reuse of materials and components is important in the transition towards a more sustainable construction industry. Reused materials are calculated as 0 kg CO_2eq in A1-A3 according to Boverket (2024a). Several interviewees see reuse as a powerful way of reducing carbon emission from these lifecycle stages and the biggest driver for customers to use reused materials in their projects. Many actors in the construction field have noticed this and have started doing their part in moving towards more material reuse. However, many of the suppliers of building materials have not been able to incorporate reused materials in their processes yet. From the interviews with clients and customers to suppliers it is clear that all of them requests to buy and order reused materials from the same place as new materials which is also identified by Mamo Fufa et al., (2023).

Understanding the customers and their underlying drivers is essential for suppliers when integrating reuse into their business. A certainty in the study is that the client is initiating reuse projects and thereby steering the demand for reused products. In many projects the clients are also involved in deciding what specific products and materials that should be reused. A process that could often lead to micromanaging and long decision times leading to additional costs. For suppliers, the clients pressure materials suppliers to be able to offer some sort or reuse concept to even be allowed to hand in a tender for supplying materials to that project. This could be a major incentive for suppliers to speed up their implementation of reuse.

For the supplier to be able to provide a successful reuse option to their clients it is almost certain that they must involve private and smaller clients into their business. These people are the ones who might not care that much about the environmental impact and saving but instead are willing to purchase products that might have lacked visual appearance or quality that are not required by them for lower costs. It is also easy for these people to purchase smaller quantities of reused materials that often are available and difficult to sell to larger projects or clients. These people and organisations often have the possibility to alter the prerequisites needed for specific materials and components which makes it easier to sell reuse products with uneven measurements and dimensions to these clients. The circular concept must be as suggested in the name, circular. This means involving all types of clients and buyers to facilitate for the different needs and requirements. By doing this it is much easier to create a circular flow of building materials and thereby facilitate for reusing materials beyond just a few innovative test-projects.

6.2 Practical aspects of material reuse

The practicality of reusing building materials has been the main focus of this study. This has resulted in a well thought framework that consider the most important aspects when evaluating the practicality of reusing different materials and components. This framework was then applied to the material categories and through interviews a substantial amount of qualitative data has been collected and analysed. This resulted in *Table 5:2* presented in the result.

To build on that table we wanted to graphically present the different material categories to better provide an overview of the supply and demand patterns and how these affect each other, see *Figure 6:1*. The base of this graph was originally sprung from the Boston Matrix which is a mean of evaluating different products based on their market share and market growth and presents this in a y and x-axis graph with four different boxes. The idea was to keep the type of graph and layout but change the different axis and definition of the boxes. After analysing and discussing multiple layouts and designs of the graph the final version was decided on which is seen below.

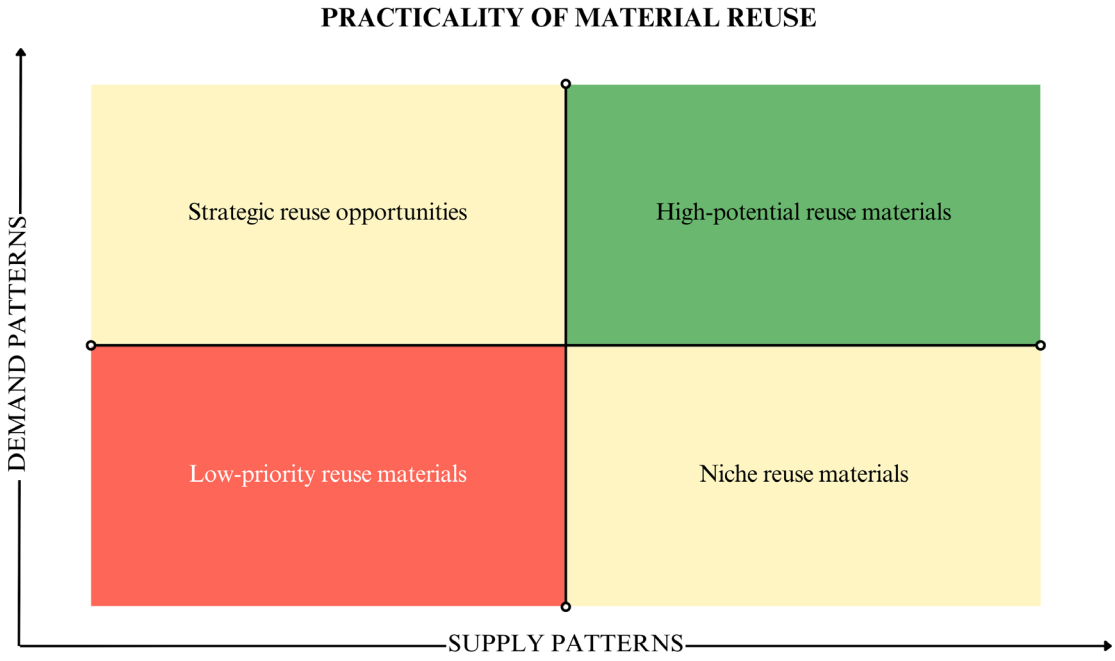

Figure 6:1 Graph describing the relation between the supply and demand patterns in practicality of reusing materials.

The two different axes represent the supply and demand patterns which has been the two main parts that the framework for evaluating materials was built on. On the y-axis a high demand pattern translates to having favourable demand aspects of that certain material or component related to the four areas of *Environmental, Cost savings, Logistics and Regulations.* The collective result of all the four areas taken from *Table 5:2* decide where on the y-axis the material group should be placed. Consequently, the x-axis relates to the supply pattern and the three areas of *Procurement, Logistics and*

Regulations. A high supply pattern in this case means that the material has favourable supply conditions of these reused materials in the three supply areas.

The different boxes or categories of the graph was developed to provide an easy and comprehensive way of quickly mapping different reuse materials and could act as a first step for a supplier when identifying potential material to reuse.

High potential reuse material*:* High supply and demand pattern where materials that today are reused to a large extent and highly demanded by customers. These materials also have easy supply processes.

Low priority reuse materials: These are categories that generally should be avoided by a supplier of reused material. They have both complicated and costly supply and demand patterns which result in a material that is not beneficial for a supplier to focus on.

Niche reuse materials: Types of materials that generally have a lower demand but could still be reused. However, they have a beneficial supply pattern and by targeting these specific categories a supplier of reused material can easily gain large market shares of this specific material.

Strategic reuse opportunities: Materials that have a high favourable demand pattern but lower supply pattern due to complicated handling and procurement etc, for example construction of ready to assemble elements. This category could generate a major reuse business if the supply pattern difficulties were solved.

After considering the demand and supply patterns based on the framework and as analysed in the result the different material groups were positioned in the graph *see Figure 6:2*. This positioning is based on an overall estimation of each material group, and it showed difficult to place these due to the number of parameters that the supply and demand pattern is based on. One can argue for a completely different position if one parameter is considered more or less important.

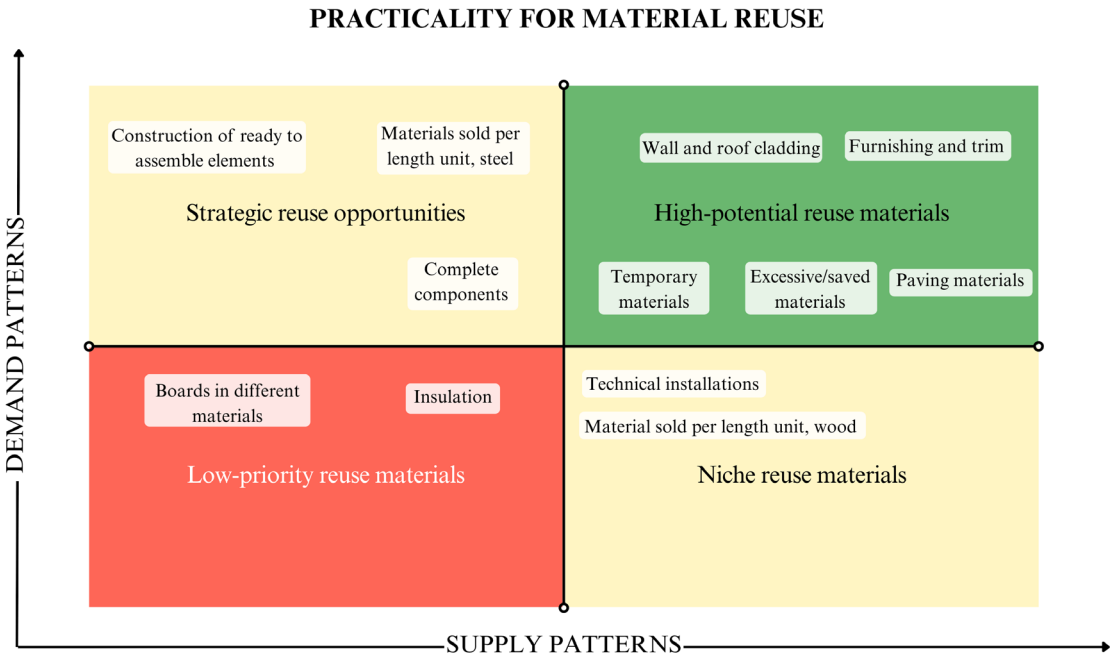

Figure 6:2 The material groups positioned on the graph based on their individual supply and demand pattern.

The positioning of the materials clearly shows that there are numerous materials that are *High-potential reuse materials.* These materials are those that have been the most practical throughout the whole study and generally is a good choice for a supplier when deciding what materials they want to supply. Here we can see temporary materials and saved materials that have been discussed in the study shows to be good when it comes to practicality. Paving materials is also a material that might go under the radar a bit but have excellent prerequisites for reuse, both supply and demand.

On the other side is the *Low priority reuse materials.* Boards is an interesting one due to the fact that there have shown to be a lot of interest in reusing boards. However, from this study it has been evident that although there might be some successful cases of reusing boards it is often very tedious and complicated, both from a supply and demand aspect which is why they are placed in this category. Which has also been confirmed by Göteborg Stad (2025). Insulation is also something that is very hard to reuse because of the fact that there are lots of different types of insulation and the logistics of this process is too complicated.

Niche reuse materials have shown to have a lower demand but can still be supplied relatively easy. Material sold per length unit wood is typically not demanded by others than private and smaller clients which decreases the demand. It is however in many cases plausible to supply these products depending on how complex the handling and logistics is. Technical installations is a group of materials that have not been reused that much in present time, but a lot of discussions are taking place about these groups of materials. Many people see potential in trying to reuse for example lighting fixtures etc and the group is therefore placed as a niche reuse option.

At last, we have the *Strategic reuse opportunities* These materials often have high demand pattern because of high environmental savings but have complicated and time-consuming supply patterns. These materials are often heavy such as joists, slabs but also complex complete components such as windows and kitchens. If these supply patterns were to be focused on, and better processes and methods were in place to handle these types of reused materials, the suppliers of these materials could gain large market shares and create a reliable reuse business. As it is today the projects reusing these types of materials often are pilot projects that aim to go by trial and error to learn, however the potential in this category is huge.

6.3 Financial aspects of material reuse

The most common concern among actors within the construction industry is the large costs often associated with circular initiatives, especially reuse, mainly due to an immature market and a low supply of reused materials, contributing to logistical challenges and higher costs. This study has investigated the most common cost drivers for reuse and the current market share of both new materials and reused materials to form a framework on which the financial aspect of different material categories can be evaluated. The evaluation is made from a supplier's perspective and aims to guide material suppliers on how to grade different materials based on their business. The results are presented in *Figure 6:3*. The y-axis presents the costs of procuring the materials, handling and transportation and costs associated with regulations. The x-axis presents the market share for reused materials to understand which materials are easy to sell.

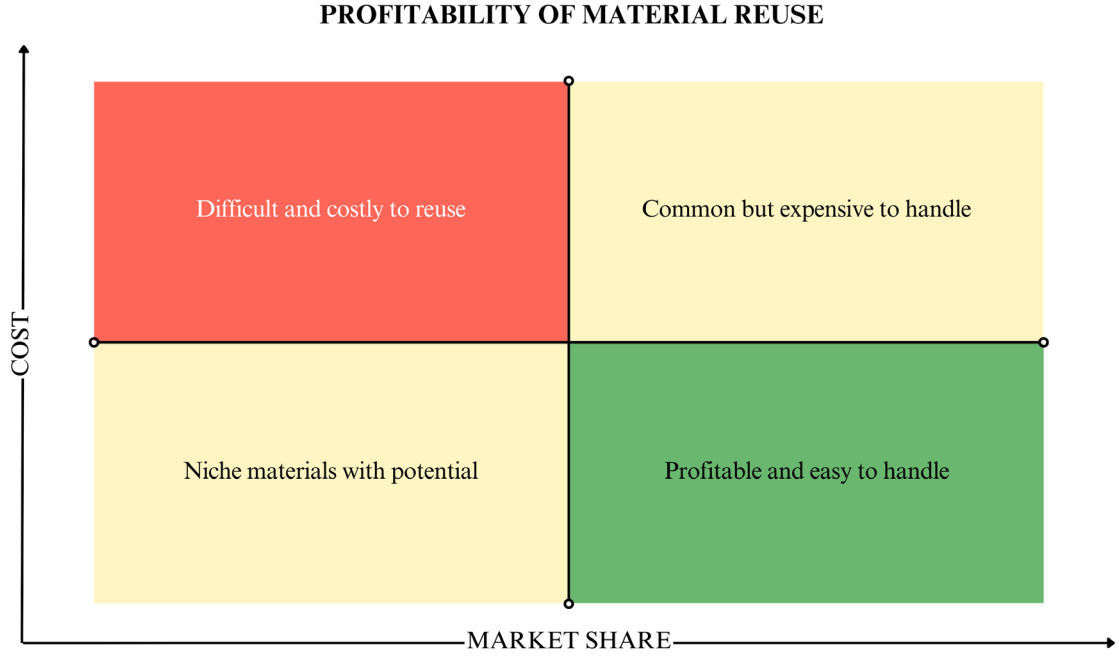

Figure 6:3 Graph describing the relation between the market share and associated cost of reused materials.

The figure results in four different fields based on their relation to costs and market share. The fields are presented below.

Common but expensive to handle are materials that have a high market share and a great potential for being sold in large quantities but are costly to handle. For these materials to be profitable, it's important to have a strategy on how to handle the material flow to make it profitable.

The second field includes the materials that are *Difficult and costly to reuse*. These materials are costly to handle and have a small market share as reused material. These materials should be avoided for a supplier to handle, except if the material category is within the company's speciality, in these cases the company might have a large market share of that specific material, making it easier for them to sell.

Niche materials with potential are materials with a low market share but that are cheap to handle. These materials can be profitable to reuse if having the right customer contacts, requesting the specific materials. When reusing these materials, it's important to consider who the end customer is, and how the company can reach that specific customer in their marketing.

The last category is the materials that are *Profitable and easy to handle.* This field consists of materials with a high market share that are cheap to handle. These materials have high potential to be profitable for a company given that they are controlling a large part of the current market since there is higher competition for the market share. The material categories have been placed in *Figure 6:4* based on their market share and costs for handling.

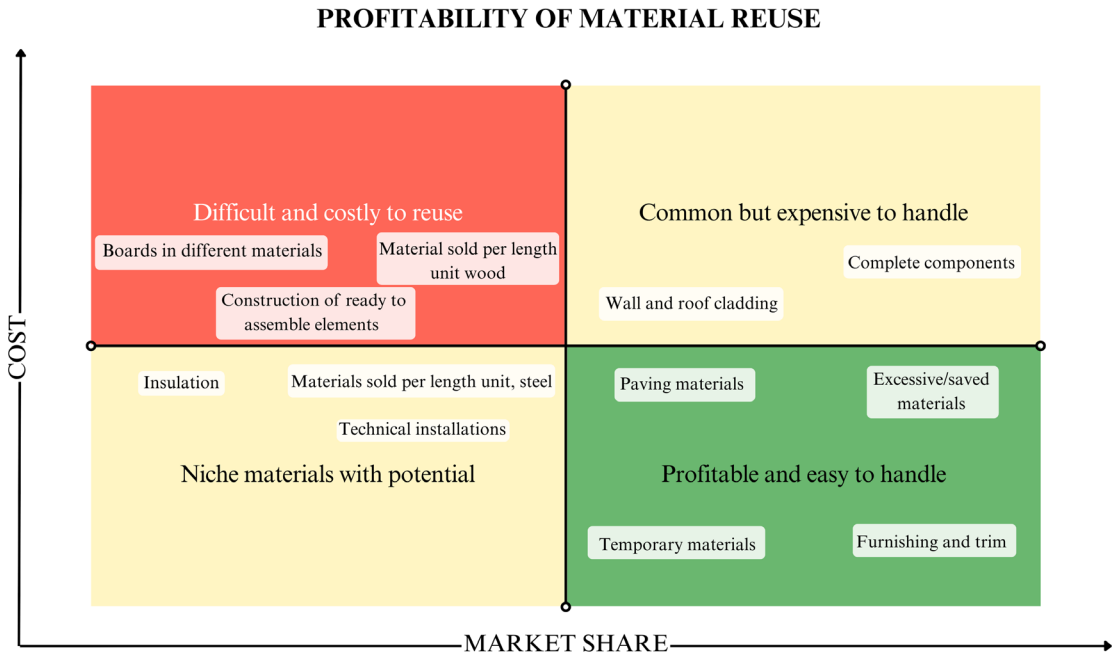

Figure 6:4 Profitability graph with different material categories positioned based on the result of the study.

Materials that are *Profitable and easy to handle* are Excessive/saved materials, Paving materials, Materials from temporary constructions and Furnishing and trim since these materials are not too costly to handle and have been reused in many projects successfully. In these categories the main materials are Paving stones for outdoor environments, Studs/boards/insulation being leftover on site and not used in a construction project, but instead of going to waste, the materials are being used in another project. Temporary materials from site setups such as structural elements temporary used on construction sites. Suspended ceiling tiles, textile carpets and WC/Sink are the most common successful examples within the category Furnishing and trim.

Wall and roof cladding and complete components have been placed in the field *Common but expensive to handle* since there are several successful examples of where this have been reused but they still require some costly handling. Reused brick and reused doors are the main materials in these categories and with an infrastructure for dismantling brick and for dismantling and refurbishing doors, these materials can also be profitable to reuse because there is a large market for the materials.

Insulation, such as stone wool and glass wool have a very low market share of reused materials since these materials can be sensitive and hard to handle. Steel studs and steel beams have been placed in this category as well because structural elements require testing which can be complicated and requires special knowledge, there is a low market share of reused steel today, but with a high demand, the market share will increase and there are several successful examples where reused steel have been used. Technical installations are another category with potential; cable ladders are easy to reuse while ventilation ducts require more handling.

Boards, especially gypsum boards, reused timber studs and larger structural elements is difficult and costly to reuse which is also confirmed by Åfreds (2025c). These materials often need costly handling and logistics, and it is hard to reuse the materials successfully and with profit.

6.4 Closing remarks

If the result and discussion of both the practicality and profitability of the different material groups are combined, we can see some patterns and answers to what the most practical and profitable materials is to reuse. The material categories identified in this study as the most practical and profitable varies heavily depending on what the end goal is. If the end goal is to have the largest environmental savings, heavy structural elements is often to be preferred. On the other hand, if the goal is to reuse material with the least amount of handling and process, complete components and furnishing and trim might instead be the one that the supplier should focus on. This study has therefore tried to systematically and methodologically present material and their different supply and

demand pattern so that everyone or anyone interested in reusing materials can take part of the information and decide from their own preferences what materials they should focus on.

The framework developed to do this have been thoroughly reviewed and presented to account for the major supply and demand aspects. It is however important to mention that there might be other factors that can play a crucial role in the evaluation of different reused materials that haven't been identified in this study. The materials that have been analysed and the grading of materials from the framework is also to be seen as only a recommendation since the reuse market is still immature and changes substantially with very short time periods. It is plausible that the materials identified as not favourable for reuse in this study will instead be favourable in a foreseeable future. The major areas of change that could impact the reuse market is for example different regulations and laws in the area. This will happen but it is just a matter of when. The construction sector will need to have definitions and regulations in place to ensure a level playing field for everyone involved. It is also a certainty that more organisations and companies will get involved with the reuse market in some way or another. As this happens more knowledge will be shared within the sector which may lead to different materials and processes being seen as the most practical ones in contrast to today's situation.

7 Conclusion

It is evident that reusing building materials is something that everyone talks about, the interest for this topic has never been higher which is proved in the industry with numerous seminars and innovative projects taking place. It is equally clear that no one really knows how to do deal with reuse in the best possible way, the idea is great, but the execution needs to be structured and based on data and research which are lacking today. The purpose of this project was to investigate which materials are most practical and profitable for a supplier to reuse to facilitate for implementing a reuse business among suppliers. This study is targeted towards suppliers in all of the construction industry who aim to incorporate reuse, in addition to this the study provides relevant information that could gain other actors involved in circular construction as well. To perform this work it was important to research the different definitions of reuse and its meaning. One of the conclusions are the lack of clear definitions of reuse, and suppliers should instead focus on offering a *circular concept* that might include different types of materials that per definition might not be reused. This can be excessive materials, second-sorted materials and over-ordered materials. It is of greatest importance not to let definitions get in the way of trying to offer a circular concept where every decrease of waste is a win.

It is although evident that an infrastructure for reuse is needed and with this, the market will expand since there is a high demand for more circular construction methods where reuse is one of the most powerful methods to reduce carbon emissions. To do this the market and the suppliers needs to know more about what materials that should be reused but also what materials that should be avoided in the field of reuse. The result of this study shows that there are potential in a major part of the materials investigated. The problems and difficulties will always be hard to overcome when trying to innovate, especially in a business known for being hesitant to radical changes. These difficulties have shown to often be related to the extra cost and time it takes to handle and work with reused material. There is however a great deal of examples of projects that successfully have reused the most complicated structural elements which shows that everything is possible.

The most practical materials to reuse is according to this study *Paving materials, Furnishing and trim, Excessive materials*, *Temporary materials* and *Wall and roof cladding* since these materials are highly demanded and have favourable supply patterns. Materials that have favourable supply patterns but have low demands are identified as “Niche reuse materials” where *Materials sold per length unit, wood* and *Technical installations* were placed. These materials could be successful to reuse with a clear end customer demanding the materials. Materials with high demand but are challenging supply were named “Strategic reuse opportunities” and consists of *Construction of ready to assemble elements*, *Materials sold per length unit steel* and *Complete components*. Regulations, and logistical challenges hinder the supply of these materials, but they are highly demanded, mainly due to large environmental savings

when reusing them. “Low-priority reuse materials” have low supply and demand making them hard to reuse, in this category *Boards in different materials* and *Insulation* were placed.

There is a strong correlation between the practical difficulties and the profitable aspects of reusing materials which results in the same material categories being favourable in both research questions and the same goes for the ones that should be avoided. The most profitable materials to reuse have a large market share today and are not too costly to handle and consists of *Excessive/saved materials, Paving materials, Temporary materials* and *Furnishing and trim*. Materials with large market share but high costs are considered “Common but expensive to handle”. *Complete components* and *Wall and roof cladding* are placed in that field. Materials with low market share and low costs are considered “Niche materials with potential”, this field consists of *Insulation, Materials sold per length unit steel* and *Technical installations*. The materials that have high costs and low market share are considered “Difficult and costly to reuse”, *Boards in different materials*, *Materials sold per length unit wood* and *Construction of ready to assemble elements* are placed in this field.

The study shows that suppliers play a crucial role in meeting the needs of customers seeking reused materials, both large contractors and private individuals. With their existing infrastructure, knowledge, and resources, suppliers must adopt some form of circular business model to effectively provide materials identified as suitable for reuse. In the future, working with reused materials will be necessary for everyone involved in the industry, and the sooner this is recognized, the better.

7.1 Future research

The study conducted have been explorative and have been performed in a research area that is still to be seen as immature and with little data at hand. If the study would have had access to more time and resources, more interviews could have been conducted as well as gathering of more quantitative data to further develop the framework and assessment of materials. Therefore, there are several areas of interest for further research and investigation.

Throughout this work it became clear that the private persons and smaller building companies could have an important role in the transformation towards more circular construction processes and implementation of reused materials. This study has not focused on these actors but have identified them as an important aspect. It would therefore be interesting to investigate more thoroughly how these actors could influence the reuse market and in what ways.

The profitability aspects which have been a smaller part of the study could further be developed and analysed. By collecting more quantitative data on costs as well as market share a more thorough analysis could be made of the profitability aspect of different

materials. This could result in business plans and feasible process plans for developing a profitable reuse market seen from the suppliers' perspective.

This study's main contribution has been development of the framework and the different aspects that should be considered when assessing materials for reuse. The assessment of these materials could further be developed. This could be made by collecting more data on each material category and in detail explain the process for different material groups. By doing this, different flows of material could be identified, from procuring of materials to the implementation as reused. This would give a more comprehensive overview of the material groups and could facilitate a more exact assessment of the different materials. A questionnaire could also be performed in combination with this to gather larger number of opinions to precisely show what materials the industry think is preferred to reuse and not to reuse. This could also be combined with the area of recycling which has been brought up by several of the interviewees. An interesting topic would be to investigate how reuse and recycling could work together to minimize the environmental impact of the construction sector.

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9 Appendix

A: Interview Guidelines Contractor

Materials and suppliers

1. How do you find reused (reclaimed) materials?
2. What is the supply of reused materials like? Has it been difficult to obtain materials?
3. Why did you use reused materials?
4. How important do you think suppliers are in the transition to more reuse?
5. What are your expectations of a reuse supplier?

Materials and Logistics

6. What type of materials did you reuse?
7. Which materials were easiest to reuse? What was the reason for that?
8. Which materials were the most convenient to reuse from a logistics perspective?
9. How did the logistics differ from handling new building materials?
10. How could a supplier have made the logistics of reused materials easier?

Economy

11. Was it economically profitable to use reused materials? Why?
12. What are you willing to pay for reused materials? Why?
13. How was the construction time affected by using reused materials?

Certification, Regulations, Laws

14. What requirements did you place on your reuse supplier regarding warranty, quality, certifications, information?
15. Were there any regulations or requirements that made handling reused materials more difficult?

B: Interview Guidelines Project Manager

Introduction

Tell us a little about yourself and your role as a project manager?

Materials and Suppliers

1. How do you work with reuse?
2. How do you define reuse?
3. Which materials have the largest supply? How do you find reused materials?
4. Why did you use reused materials?
5. How important do you think suppliers are in the transition to more reuse? What are your expectations of a reuse supplier?

Materials and Logistics

6. What type of materials did you reuse?
7. Which materials are easiest to reuse? What is the reason for that?
8. Which materials were the most convenient to reuse from a logistics perspective?
9. How does the logistics differ from handling new building materials?
10. How could a supplier have made the logistics of reused materials easier?

Economy

11. Is it economically profitable to use reused materials? Why?
12. What are you willing to pay for reused materials? Why?
13. How was the construction/planning time affected by using reused materials?

Certification, Regulations, Laws

14. What requirements did you place on your reuse supplier regarding warranty, quality, certifications, information?
15. Were there any regulations or requirements that made handling reused materials more difficult?

C: Interview Guidelines Suppliers

Introduction

1. How do you define reuse?
2. How do you think suppliers are important in the transition to more reuse and circular construction?

Material Procurement

3. How do you acquire your materials?
4. Do you pay for the materials?
5. Which materials have the highest availability?
6. How much of your material is reused and how much is surplus (leftover) material?

Logistics

7. Which materials are the easiest to handle?
8. How do you handle the materials you receive?
9. Do you exclude certain materials due to logistical challenges?

Certifications, Regulations, Laws

10. Do you offer warranties on your products? Why?
11. Do you reclassify materials from waste to product? If so, how?
12. Do your products carry any certifications, like CE marking?
13. Are there additional costs for quality assurance and product warranties?

Economy

14. Which materials are in the highest demand? Which materials do you sell the most of?
15. Which materials have the most expensive handling?
16. How long do you store your products?