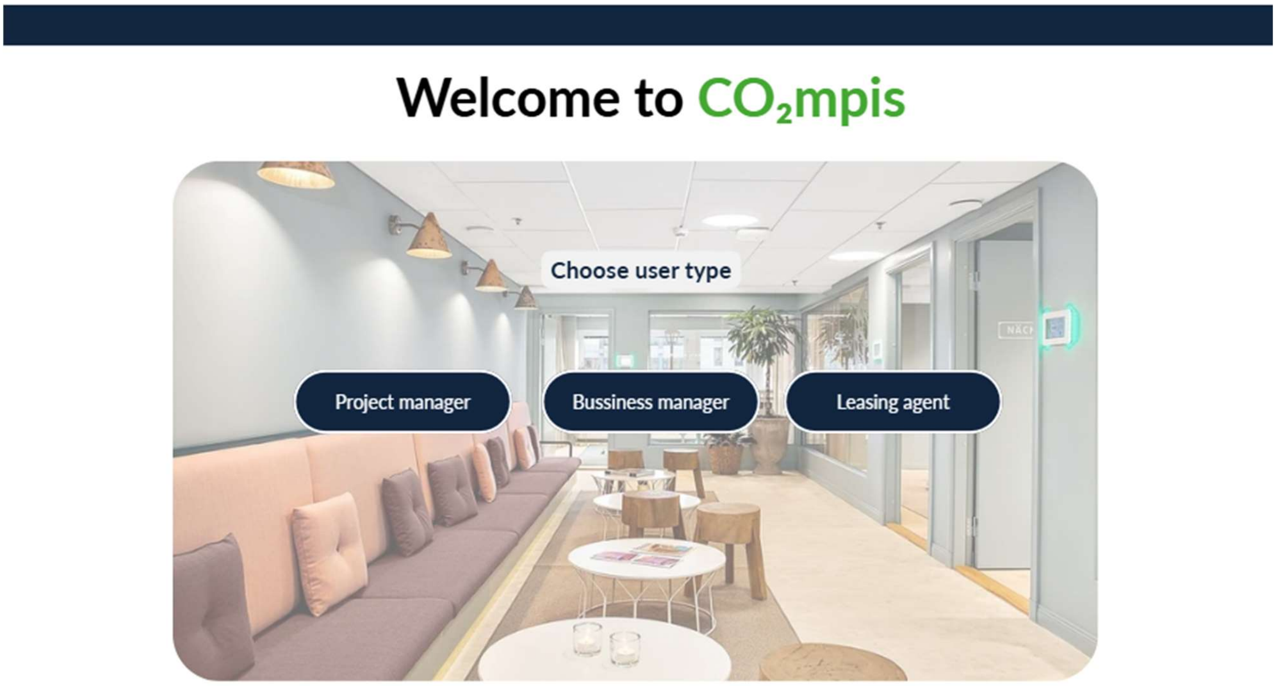

CO_2mpis – A Tool for CO_2 Reduction in Fit-Outs

Wireframe-development of the communication tool CO_2mpis

Master's thesis in Design and Construction Project Managment & Industrial Ecology

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DIVISION OF BUILDING TECHNOLOGY

CHALMERS UNIVERSITY OF TECHNOLOGY
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MASTER'S THESIS ACEX30

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Cover:
Interface of the tool CO_2mpis, authors own figure.

Department of Architecture and Civil Engineering
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ABSTRACT

The building and construction sector is responsible for a large share of global carbon emissions and extraction of material resources. Within the construction sector, one significant contributor is fit-outs. A fit-out is the process when a commercial space is customized to meet tenant needs. Fit-outs are done frequently from a lifecycle perspective, consequently leading to large amounts of carbon emissions.

The aim of this thesis is to facilitate the reduction of CO_2 emissions in fit-outs. The thesis is designed to apply to the real estate company Vasakronan and is conducted in a Swedish context. To realize the aim, Circular economy (CE) was applied to facilitate sustainability in fit-outs. However, implementation of circular economy into fit-out projects is a complex process. Fit-outs are multifaced and tenants' opinions and wishes can become hinders. To enable CEs implementation, efficient communication between real estate owners and tenants is crucial. This thesis seeks to overcome the communication gap, by creating a communication tool for material selection named "CO_2mpis". Interviews with actors at Vasakronan were held to identify their needs in a communication tool. The needs were specified using user stories. Based on these, a wireframe was developed using insights from a market scan, hotspot analysis and development of a CE framework. The findings were used to create the functionalities included in the wireframe. This includes compering materials carbon emissions, visualizing differences (e.g., reused vs. new materials), and expressing them in relatable terms, such as numbers of plane trips. The tool also enables comparison of different projects and suggests circular strategies for materials. The results show how the gap in communication can be overcome by implementing CO_2mpis.

Key words: Fit-out, CO_2 reduction, Circular economy, Communication Tool, Material selection

CO_2mpis – Ett verktyg för CO_2-reduktion i lokal-anpassningar
Utveckling av wireframe för kommunikationsverktyget CO_2mpis

Examensarbete inom masterprogrammen Organisering och ledning i bygg- och fastighetssektorn & Industriell ekologi

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SAMMANFATTNING

Bygg- och anläggningssektorn står för en stor andel av de globala koldioxidutsläppen och uttagen av naturresurser. Inom byggsektorn är lokalanpassningar en stor del av dessa utsläpp. En lokalanpassning är processen då en kommersiell lokal anpassas efter hyresgästens behov. Lokalanpassningar sker ofta sätt från ett livscykelperspektiv och bidrar därmed till stora mängder koldioxidutsläpp.

Syftet med detta examensarbete är att underlätta reduktionen av CO_2-utsläpp vid lokalanpassningar. Arbetet är utformat i samarbete med fastighetsbolaget Vasakronan och genomförs i en svensk kontext. För att uppnå syftet med arbetet applicerades cirkulär ekonomi (CE) för att underlätta hållbarhets vid lokalanpassningar. På grund av lokalanpassningars varierade förutsättningar, med skiftande önskemål och preferenser från hyresgäster, är implementeringen av CE en komplex process. För att möjliggöra detta krävs effektiv kommunikation mellan fastighetsägare och hyresgäster. Detta arbete syftar till att överbygga kommunikationsbristen genom att utveckla ett kommunikationsverktyg för materialval, kallat "CO_2mpis". Intervjuer med aktörer på Vasakronan genomfördes för att identifiera deras behov av ett sådant verktyg. Behovet specificerades genom så kallade user stories. Utifrån dessa utvecklades en wireframe med stöd av en marknadsanalys, en hotspot-analys samt ett ramverk för cirkulär ekonomi. Resultatet från de nämnda metoderna låg till grund för de funktioner som integrerades i wireframen. Resultaten inkluderar jämförelser av materials koldioxidutsläpp, visualisering av skillnader (t.ex. återbrukat kontra nytt material) och uttryck av utsläppen i relaterbara termer, såsom antal flygresor. Verktyget möjliggör även jämförelser mellan olika projekt och föreslår cirkulära strategier för materialval. Resultatet visar hur kommunikationsbristen kan överbryggas genom att implementera CO_2mpis.

Nyckelord: Lokalanpassning, CO_2 reduktion, Cirkulär ekonomi, Kommunikationsverktyg, Materialval

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Preface

This thesis was carried out as the final part of our education at Chalmers University of Technology. It marks the concluding step of our Master's programs in Design and Construction Project Management and Industrial Ecology. The thesis was conducted within the Department of Architecture and Civil Engineering during the spring of 2025.

We would like to thank our academic supervisor, Leonardo Rosado, for his invaluable guidance and support throughout the entire process. We also want to thank Vasakronan for their collaboration and for generously sharing their expertise, with special thanks to our company supervisor, Amanda Höjer, for her continuous support and encouragement.

Göteborg June 2025

LISA HELLSTRÖM

FILIPPA PAMP

Glossary and Acronyms

The thesis is conducted in a Swedish context, the following terms are used throughout the report. To clarify the terms, translation to Swedish and a list of acronyms is provided.

Fit-out	Lokalanpassning
Pre-lease fit-out	Förtidalokalanpassning
Project calculations	Projektkalkyler
Decision memo	Besluts PM

BVB	Byggvarubedömningen
CE	Circular Economy
CSRD	Corporate Sustainability Reporting Directive
GHG	Greenhous gas
HVAC	Heating, ventilation, and air conditioning
PPT	Product, Price, Time
QUS	Quality User Stories

The actors at Vasakronan

When the actors at Vasakronan are mentioned throughout the thesis, it's the followings roles below that are being referred to.

Project manager (PM) - Projektchef

The project manager is responsible for supervising the fit-out projects from start to finish. In many projects, Vasakronan also hires a consultant project leader who handles the more detailed aspects of the project, such as day-to-day operations, coordination with contractors, and ensuring deadlines are met. The project managers role includes managing all phases of the project, from initial planning and coordination to the execution and completion.

Business manager (BM) - Affärsansvarig

The business manager is responsible for managing tenant relationships and developing strategies to optimize office building value and occupancy. This includes renegotiating lease agreements and addressing tenant inquiries about their premises or the building in general. The role also focuses on improving tenant retention and marketing office spaces to align with business goals.

Leasing agent (LA) - Uthyrare

The leasing agent is responsible for the rental process of commercial spaces, from showcasing properties to potential tenants to negotiations and finalizing leasing agreements. This role includes close communication with potential tenants, marketing available spaces, and understanding the market to attract clients.

Technical manager (TM) - Teknikansvarig

The technical manager is responsible for the technical and operational management in the properties. This includes strategic maintenance planning and ensuring that buildings function effectively, with a focus on maintaining customer satisfaction through collaboration with service partners.

1 Introduction

Climate change is one of the biggest global challenges we face today. According to the IPCC 2023 report (IPCC, 2023), the global temperature is on track to exceed 1.5 degrees Celsius, compared to pre-industrial times if effective actions are not put in place to reduce greenhouse gas emissions. Without intervention we will see critical consequences such as rising sea levels, extreme weather events and disruptions in ecosystems.

According to the European Commission (n.d.) human activities are major drivers of climate change, with the building and construction sector representing a significant contributor. This sector consumes large amounts of resources, and material extraction accounts for 37% of total greenhouse gas (GHG) emissions, with construction materials and processes representing the largest share (UNEP, 2023). In line with this, the largest share of CO_2 emissions within the real estate industry stems from scope 3 emissions, representing indirect emissions from material production and supply chains (Fastighetsägarna, 2022). In Sweden, the building and construction sector was responsible for 22% of all GHG emissions in 2022 (Boverket, 2025). Given this substantial contribution, it is crucial to focus on strategies to reduce emissions in this area.

One domain within the construction sector, that is especially interesting in terms of carbon emissions is fit-outs. A fit-out is the process when a commercial space is customized to fit a tenant's needs. When a new tenant takes over the space, replacement of components is common, typically occurring every 3-10 years, and results in substantial material consumption (Casas-Arredondo, 2021). Furthermore, an office fit-out project in Sweden can generate 30-80 kg CO2e per square meter (AMF Fastigheter, n.d.). This represents a signific environmental impact, especially given that a building can experience between 30-40 fit-outs over its lifespan (Casas-Arredondo, 2021). To support the reduction of CO_2 emissions in fit-outs, the concept of circular economy is particularly relevant (Ellen MacArthur Foundation, n.d.-b).

A circular economy (CE) is a concept in which materials never become waste but are instead kept in circulation (Ellen MacArthur Foundation, n.d.-c). The circular economy has gained increasing attention in recent years. However, there is a lack of research, both in practice and in literature, regarding CEs implementation in fit-out projects. For example, the study by Casas-Arredondo (2021) found multiple barriers in implementing circular economy principles in practice. Among the barriers found were economic, regulatory, informational, technical, organizational and behavorial.

Another study on circular fit-outs by Fierens (2024) determined that future studies should focus on analyzing the carbon footprint of fit-out projects to identify reduction opportunities and develop guidelines to support circular practices. Furthermore, Fierens points out that the transition to circularity in fit-outs relies heavily on the relationship and communication between the real estate owner and the tenant. This importance of communication is also emphasized by Delnavaz (2012), who underscores that facilitating effective communication among stakeholders is essential to manage the multifaced aspects of sustainable building projects.

1.1 Problem formulation

A key challenge in enabling circularity in fit-outs is inefficient communication between real estate owners and tenants. This gap hinders sustainable decision-making in projects. To address this, improved communication support is needed. Currently, few tools are available on the market to assist real estate owners in implementing circular construction practices such as CIX (CIX, n.d.), Madaster (Madaster, 2025), Building Circularity Tool (One Click LCA, 2025), CCBuild (CCBuild, n.d.) and Circularity dashboard by (CIRCuIT, 2020). However, there is currently no dedicated tool specifically developed for fit-outs that facilitate communication with tenants. This thesis provides new insights bridging theory and practice, developing a wireframe of a tool to support communication and reducing CO_2 emissions related to fit-out projects.

This research is within the field of construction, specifically focusing on fit-out projects. The thesis investigates how the communication process, specifically related to material selection, can be supported through a tool. To conduct applied research, the thesis is carried out in collaboration with Vasakronan. The work includes conducting interviews, scanning the market for existing tools, identifying CO_2 hotspots in fit-out projects, developing a circular economy framework and creating a communication tool.

1.2 Aim and research questions

The aim of this thesis is to facilitate the reduction of CO_2 emissions in Vasakronans fit-out projects. This is done by creating a wireframe of CO_2mpis, a tool that enhances communication and supports informed material selection decisions. The tool is intended to support the different actors involved in the material selection process at Vasakronan. In this context, the actors refer to the Project manager, Business manager, and Leasing agent. To realize this aim the following research questions have been developed:

- **RQ1.** What are the communication needs related to material selection for different actors at Vasakronan?
- **RQ2.** How can a tool be designed to meet the specific needs of its intended users?
- **RQ3.** How can the necessary information for the tool's functionalities be collected?

1.3 Delimitations

This thesis is done in a Swedish context, delimited to fit-out projects done by one real estate company Vasakronan. The decision to narrow the scope to not include additional property owners was made to be able to conduct a deeper analysis and thereby get accurate data leading to valuable insights into the fit-out process. Vasakronan mainly owns and manages commercial buildings, therefore the study only investigates fit-out projects in commercial buildings. Furthermore, Vasakronan has identified material use (scope 3 emission) as a major contributor of its CO_2 emissions

(Vasakronan, 2024). Consequently, this thesis focuses on Scope 3 emissions stemming from material use. To narrow down the scope of the thesis, other emission contributors such as transportation to the project sites and waste generation are not included.

Another delimitation is related to the type of fit-out projects included in the analysis. 7 different fit-out projects with a floor area range between 330 - 2543 square meters and in a cost range of 1 – 16 Mkr were analyzed. Typically, a small office space for a fit-out process at Vasakronan is around 150-200 m^2 and a large space 1000-2000 m^2, thereby the floor range used for the thesis is determined to be a good representation of a medium to large sized project (A. Höjer, personal communication, February 3, 2025).

1.4 Ethical and social aspects

The thesis was made in collaboration with the property owner Vasakronan in Gothenburg. As companies may hold sensitive information, permission from Vasakronan on what information could be disclosed was obtained. Furthermore, an NDA (non-disclosure agreement) was signed. Interviews were conducted with participants who were informed about the aim of the thesis, and their identities anonymized to protect their privacy. Furthermore, the interviews were conducted by first asking the respondent if they agreed to the interview being recorded. Another aspect where careful deliberation was conducted was in regard to the interview material. Once thesis was complete, all files containing interview material were removed to ensure participant anonymity.

2 Theoretical framework

This section will provide background on fundamental concepts and frameworks necessary to understand and follow the study. First, the concept of fit-outs and what it involves together with the fit-out process at Vasakronan are presented. Secondly, circular economy (CE) and various frameworks are presented. Finally, the concept of user stories and wireframing are explained.

2.1 Fit-out projects

A fit-out refers to the process of equipping a commercial interior space, for example an office, with all necessary elements to meet the commercial tenant's requirements (Tawasha, 2022). Typically, this process involves construction of flooring, standard floor and ceilings, HVAC, plumbing and restrooms. In the Building Shearing Layers Model, as can be seen in Figure 1, activities in a fit-out includes components in the service, space plan and stuff layers (Casas-Arredondo, 2021). The purpose of a fit-out is to adapt the space for the tenant's specific operation. It is important to note that a fit-out is different from a renovation. Whilst a renovation aims to restore a space to good condition, a fit-out focuses on customizing the space to meet the unique needs of a specific client (Gerhardsson et al., 2019). Every fit-out is different depending on the needs and the current condition of the space but generally they are performed between different tenants (Connor Construction, n.d.).

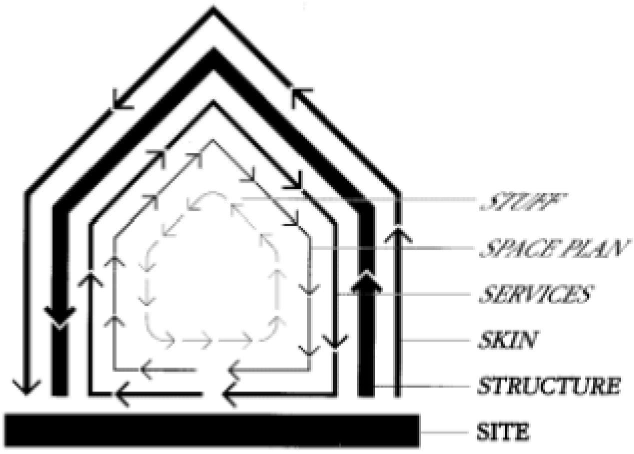

Figure 1. Building Shearing Layers Model (Brand, 1994).

Based on research on what different commercial real estate companies offer, they typically provide three types of concepts: fully equipped offices, pre-lease fit-outs, and customized solutions (Castellum, 2025; Vasakronan, 2025; Wallenstam, 2025). The fully equipped offices are furnished and include everything needed in an office, usually offered with shorter rental contracts. The second concept, pre-lease fit-outs, allows for small adaptations, and the tenant needs to bring their own furniture, however everything else is provided. The last concept involves a customized office tailored to the specific tenant, where the property owner and client collaborate to adapt the space to their needs. The main difference between the three concepts is whether they are made with or without a tenant. The move-in ready and pre-lease fit-outs are done without a tenant while the customized fit-outs are made with a tenant.

Since this thesis focuses on communication on material selection with tenants, it will primarily focus on customized offices.

Typical actions that are included in a fit out can be seen in the study by the Swedish Environmental Research Institute (Svenska Miljöinstitutet, 2021). They conducted a study on the reuse potential in fit-out projects and investigated three different fit-out scenarios and what is often replaced in a fit-out. These three scenarios include: 1) refreshment and new finishes, 2) new finishes and some redesign of the floorplan, and 3) total redesign. The findings are based on fit-out projects in the Gothenburg region, and Table 1 below shows the percentage of product quantities that are replaced.

Table 1. General products expected to be replaced in a fit-out in the Gothenburg region (Svenska Miljöinstitutet IVL, 2021).

Product type		Scenario 1	Scenario 2	Scenario 3	Average Percentage that is replaced.
Inner doors		10%	50%	100%	53%
Glas panels		10%	50%	100%	53%
Textile carpet		50%	75%	100%	75%
Wood floor		50%	75%	100%	75%
Lighting fixtures		10%	50%	100%	53%
Ceiling panels		10%	50%	100%	53%
Kitchen	Cabinet frames	10%	100%	100%	53%
Kitchen	Cabinet doors	50%	100%	100%	75%
Kitchen	Countertop	50%	100%	100%	75%
Kitchen	Sink unit	10%	50%	100%	53%
Kitchen	Refrigerator/freezer	10%	50%	100%	53%
Kitchen	Dishwasher	10%	50%	100%	53%
Kitchen	Microwave	10%	50%	100%	53%
Toilet/ Accessible toilet	Toilet seat	10%	50%	75%	45%
Toilet/ Accessible toilet	Sink and tap	10%	50%	75%	45%
Toilet/ Accessible toilet	Mirror	50%	75%	100%	75%
Toilet/ Accessible toilet	Hooks	50%	75%	100%	75%
Toilet/ Accessible toilet	Soap dispenser, trash Bin and sanitary holder	50%	75%	100%	75%

Toilet/ Accessible toilet	Toilet paper holder	10%	50%	100%	53%
Toilet/ Accessible toilet	Accessible armrest	10%	50%	100%	53%
Toilet/ Accessible toilet	Shower tap	10%	50%	100%	53%

To gain a better understanding of what a fit-out can look like, two examples from the property owner Vasakronan are shown in the figures below, Figure 2 and 3. The examples include an open office space and the other a kitchenette. Both examples are less extensive fit-outs and can be categorized as scenario 1 based on IVL's scenarios.

Figure 2. Example of a fit-out in an open office space, to the left the old design and to the right the new. Pictures provided by Vasakronan.

Figure 3. Example of a fit-out in a kitchenette, to the left the old design and to the right the new. Pictures provided by Vasakronan.

2.2 The fit-out process at Vasakronan

This thesis focuses on fit-outs at Vasakronan, therefore this section will explain the fit-out prosses at Vasakronan. Every project is unique and depending on the extent of the fit-out, size of the office space, type of tenant and their business, the scope and process can vary greatly. But generally, the fit-out process starts when Vasakronan knows that they are going to get a vacant office. In Figure 4 below the general steps of a fit-out are shown.

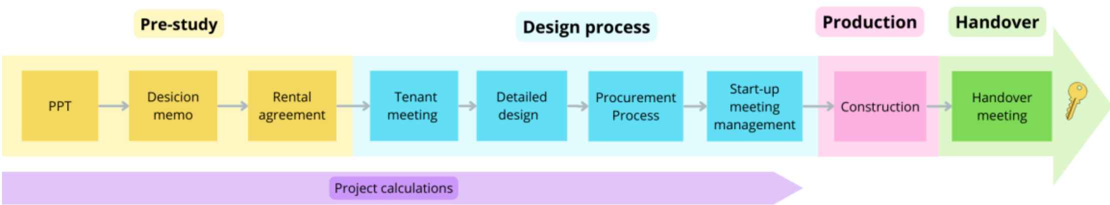

Figure 4. The fit-out process at vasakronan.

The first step in the fit-out process at Vasakronan is a pre-study including the PPT (Product, Price, Time), decision memo and rental agreement. In the PPT process the different actors at Vasakronan: the Business manager for the building, the Leasing agent, Project manager and the Technical manager work together. During the PPT-process the space and what is needed to be done is evaluated. Does it need a lot of restoration or is only a fresh coat of paint needed? What is the estimated price for the fit-out? How long will the fit-out take and when can the new tenants move in? Once the questions have been answered there are some different paths that can be taken. Vasakronan can themselves do the fit-out, a “pre-lease fit-out’’ before finding a new tenant. In that case, once the fit-out is complete it is published online and ideally a new tenant is interested and moves in. Alternatively, once an interested tenant comes along, the fit-out process can be done in collaboration between Vasakronan and the new tenant. This type of fit-out project is therefore much more customized to the needs and wants of the tenant compared to an “pre-lease fit-out’’. To get approval to proceed with the fit-out project a decision memo is signed within the company. If the fit-out project is done together with a tenant, a rental agreement is signed before the process starts.

After the pre-study the design process starts. The main steps in the design process include tenant meetings, detailed design, the procurement process and a start-up meeting. The tenant meetings are held multiple times throughout the process in order to understand the tenant's needs and communicate how the project is going. In the detailed design the construction documents and blueprints are developed. Once the documents are completed the procurement process starts and a start-up meeting for management is held. When the design process is finished the next phase, the production phase, starts. Which includes the construction where the contractors build, polish and install the agreed upon components in the space. Once the construction is done and a final inspection is approved, the new tenant gets access to their new office space.

Through the whole fit-out process “project calculations” in pre-designed excel sheets are used. The excel sheets include cost- and CO_2 calculations for different actions and materials that are used in fit-out projects, there is also information about the proportions of recycled and renewable material. The project calculations are used to calculate cost and CO_2 emissions in the projects and are carried out by the project managers at Vasakronan and are primarily used for internal communication.

2.2.1 Material selection for fit-outs at Vasakronan

Since projects can vary from one another there is no specific process for selecting materials for fit-outs at Vasakronan. Some tenants are not very invested in material selection whilst others are very selective and specific about their wants and needs for the space. Furthermore, some tenants have an interior designer that has a large influence on the chosen materials in the fit-out. (A. Höjer, personal communication, January 20, 2025).

However, Vasakronan has a “Reuse hierarchy” that is used to support them in material selection. The hierarchy includes five stages, Reuse within floor plan, Reuse of building component on-site, Reuse from another location, Upcycling and New materials, shown in Figure 5. The first two stages means that the floor plan and existing components in the office space are kept, for example by reusing the existing doors. Stage three includes obtaining reused materials from another project or actor, for example CCBuild (CCBuild, n.d.) or Klaravik (Klaravik, n.d.). These are websites where reused items can be bought or sold online. The fourth stage includes upcycling materials, meaning using them in another way or format, for example as art.

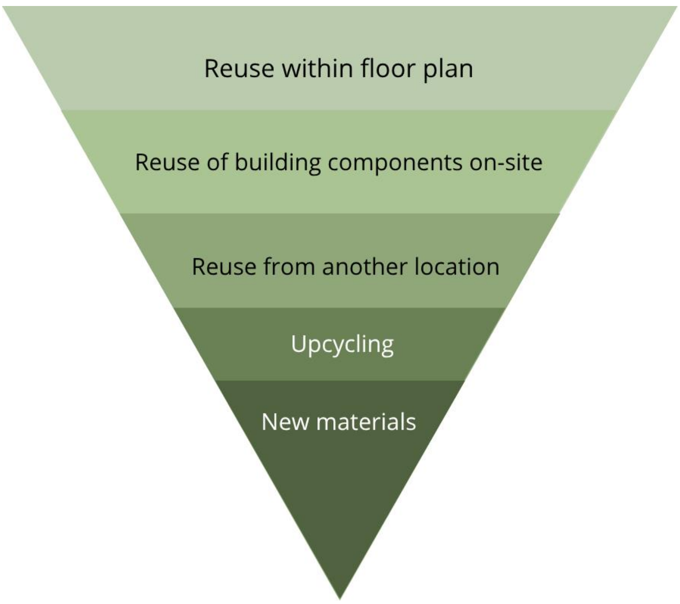

Figure 5. Reuse hierarchy

The fifth and last stage is new materials. For new materials Vasakronan has a set way of accepting materials, see Figure 6. The first part is that the material needs to be accepted in Byggvarubedömningen (BVB), a building material assessment, to assist in avoiding materials that are harmful to health and the environment (Byggvarubedömningen, n.d.). Next, materials with a high content of recycled and renewable components are chosen. Thereafter, materials with low CO_2 emissions are used, along with materials that are easy to reuse.

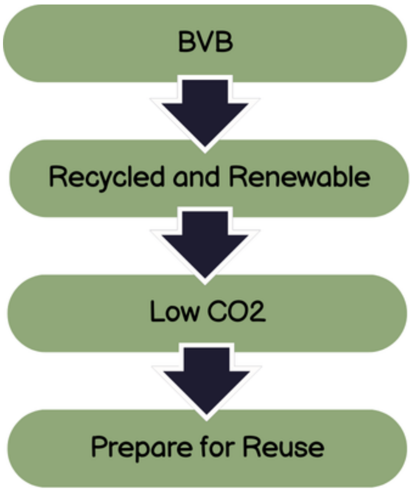

Figure 6. Guidelines on selecting new materials

In addition to the "Reuse hierarchy" Vasakronan works with a circularity index to measure and strive towards circularity in their fit-out projects. The circularity index that Vasakronan uses calculates the share of reused, recycled and renewable materials in projects (Vasakronan, 2024), see equation 1. The circularity index is an important part of their sustainability work and helps reduce emissions generated through material use. Vasakronan uses the circularity index as an annual target, setting a specified percentage each year and working towards it in their projects. (R. Skantze, personal communication, January 30, 2025).

$$CircIndex = \frac{Reused\ [kg] + Recycled\ [kg] + Renewable[kg]}{Total\ \ material\ [kg]} \qquad \text{(eq. 1)}$$

2.3 Circular economy

The concept of circular economy (CE) has various interpretations, and a single definition is yet to be agreed upon. Despite lack of unanimous agreement upon its definition, its implementation and popularity is growing rapidly (Kirchherr et al., 2017). This thesis adopts the CE definition as defined by the Ellen MacArthur Foundation. The definition goes as follows:

> "*The circular economy is a system where materials never become waste and nature is regenerated. In a circular economy, products and materials are kept in circulation through processes like maintenance, reuse, refurbishment, remanufacture, recycling, and composting.*"
> - (Ellen MacArthur Foundation, n.d.-a)

The definition is built on three principles: Eliminate waste and pollution, Circulate products and materials and Regenerate nature. To integrate the circular economy perspective and strategies into the fit-out process different frameworks were analyzed. The CE framework used in this thesis was the *Circular fit-out in retail stores* by Arup (2022), which in turn includes the 9R framework by Kirchherr et al. (2017). Below the two frameworks are explained.

2.3.1 The 9R Framework

A common definition of circular economy is through the hierarchically ranked R-imperatives. Various frameworks apply different numbers of R-strategies, ranging from 3 to 10 Rs (Reike et al., 2018). Based on the work by (Kirchherr et al., 2017) the different R-strategies can be categorized into different categories: *Smarter product use and manufacture*, *Extend lifespan of product and its parts* and *Useful application of materials*. The R-strategies within Kirchherr's framework, the 9R framework, follows: Refuse, Rethink, Reduce, Reuse, Repair, Refurbish, Remanufacturing, Repurpose, Recycle and Recover (Kirchherr et al., 2017). The hierarchy of the 10 strategies in the framework are shown in Figure 7, below.

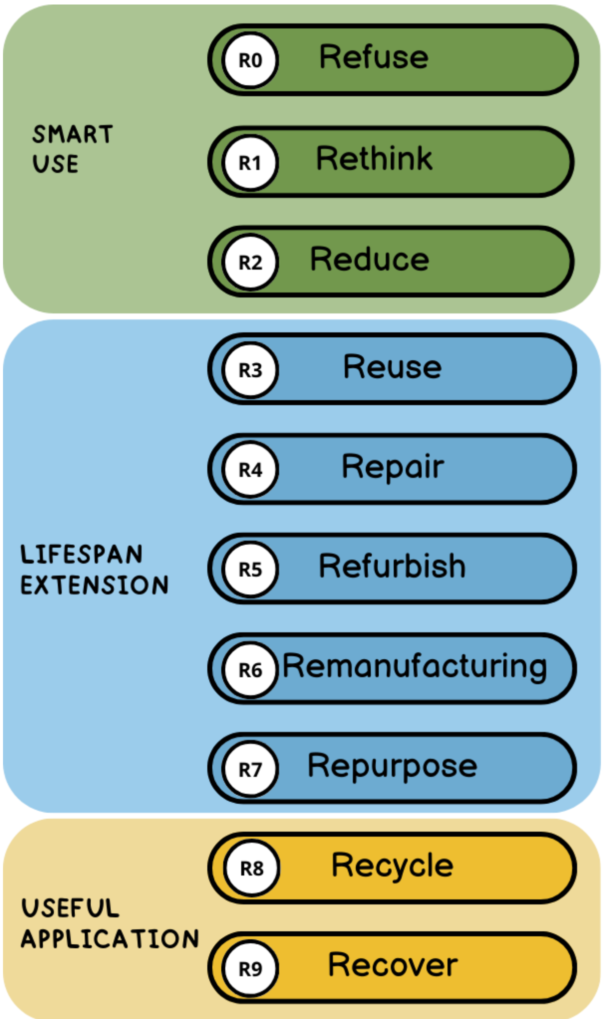

Figure 7. Strategies in the 9R Framework.

The first category, smart use, includes the strategies *Refuse, Rethink* and *Reduce*, which focuses on smarter products and manufacturing. The three strategies apply different perspectives on this. Refuse refers to preventing resource use by avoiding unnecessary products. Rethink aims to optimize product use by sharing or improving efficiency whilst, Reduce focuses more on the manufacturing and using less resources in the production.

The second category, lifespan extension, includes the strategies *Reuse*, *Repair*, *Refurbish, Remanufacturing*, and *Repurpose*, where products are upgraded to extend their lifespan. All these strategies have the same focus but with different approaches. Reuse involves using a product again without modification, while Repair focuses on fixing a product to keep it functional. With Refurbishing and Remanufacturing, the aim is to upgrade the product for better performance, ensuring it remains useful for a longer time. Repurpose, on the other hand, differs from the others by reusing materials for a completely different function rather than maintaining their original purpose.

Finally, the third category, useful application, focuses on alternative material applications and includes *Recycle* and *Recover*. Recycle refers to the process of breaking down waste into raw materials and Recovery to incineration of material for energy recovery.

2.3.2 Circular fit-out in retail stores

Circular fit-out in retail stores is a framework developed by the global consultancy firm Arup (2022). The framework presents circular design strategies that are relevant in a fit-out process with the goal of transitioning toward a circular built environment (Arup, 2022). The framework was developed based on the three main circular economy principles by Ellen MacArthur Foundation, the 9R framework and the resource loops strategies. The resource loops include narrow, slow and close (Bocken et al., 2016). The narrow loops aim to design to allow for smarter product use. The Slow loops aim to expand product lifespan and allow for multiple uses whilst, the Close loops aim to allow for material recovery at end-of life.

In addition, Arup's framework has identified circular design principles. In Figure 8 below, the framework is shown. The three bigger red circles depict the resource loops, the smaller red circles depict the 9R framework strategies and the gray rectangles, the circular design principles.

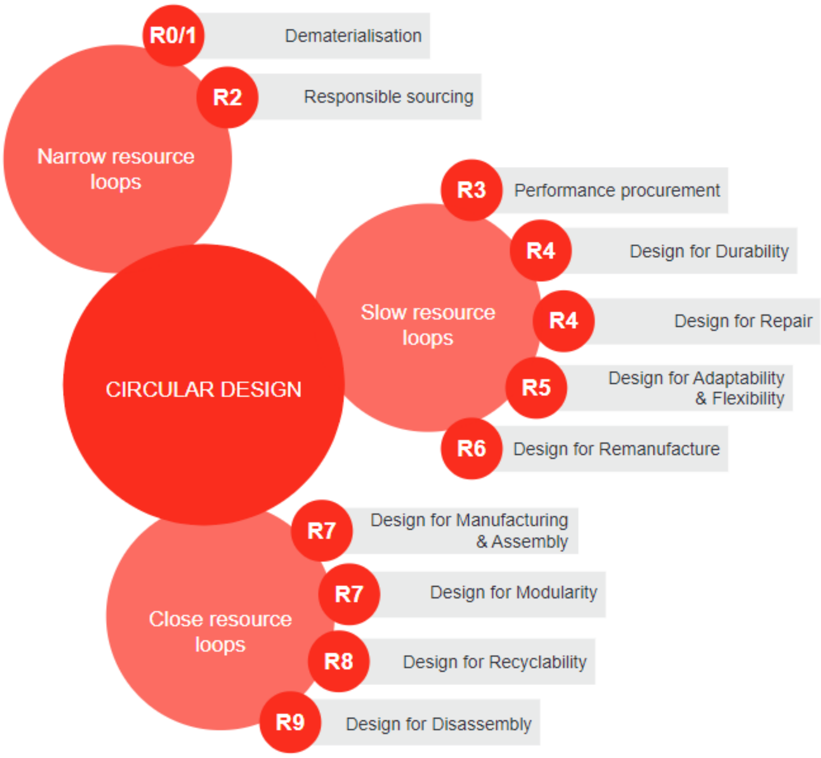

Figure 8. Circular design strategy framework by Arup 2022.

Narrow resource loops include the 9R strategies R*efuse* (R0), *Rethink* (R1) and *Reduce* (R2), and the circular design principals *Dematerialization* and *Responsible sourcing. Dematerialization* aims to create the same service or product with less or no material and *Responsible sourcing* means to use materials that are renewable and sustainable.

Slow resource loops include *Reuse* (R3), *Repair* (R4), *Refurbish* (R5) and *Remanufacture* (R6) from the 9R framework. The connected design principals are *Performance Procurement, Design for Durability, Design for Adaptability & Flexibility,* and *Design for remanufacture*. *Performance Procurement* is to have co-ownership and thereby maximize product utilization. *Design for Durability* means to design a product for a long lifespan. *Design for Repair* means that parts are easily accessible and thereby easy to repair. *Design for Adaptability & Flexibility* aims to hinder premature obsolescence by designing for adaptation. Lastly, *Design for remanufacture* refers to reuse parts of discarded products.

Close resource loops include the 9 R strategies *Repurpose* (R7), *Recycle* (R8) and *Recover* (R9) and the design principles *Design for Manufacturing & Assembly, Design for Modularity, Design for Recyclability* and *Design for Disassembly. Design for Manufacturing & Assembly* aims to create products that are easily manufactured in an efficient way. The aim for *Design for Recyclability is* that products should be easy to recover and recycle at end-of-life. The aim for the principle *Design for Disassembly* is that components and products can be deconstructed at end-of-life and

Design for modularity aims to establish standards and uniformity in processes and materials.

2.4 User stories

To develop a tool for the actors at Vasakronan, the Project manager, Business manager and Leasing agent, it is essential to understand their roles and needs. This ensures that the tool meets their requirements in communicating material selection. One method that can be used to clearly define these needs is User stories.

In software development User stories are commonly used in agile software development. They are notations used to express requirements from a user's point of view. These requirements are written in natural language in a semi-structured way (Raharjana et al., 2021). The general idea is that three basic components can be used to describe a user story, these three components are *who*, *what* and *why* (Lucassen et al., 2016). A popularized version widely accepted was developed by Mice Cohn follows: “As a (type of user), I want (goal), so that (some reason)” (Raharjana et al., 2021).

Today there are multiple methods and approaches to work with user stories one of those is the quality user stories (QUS) (Lucassen et al., 2016). The QUS consists of 13 quality criteria's that should be followed when writing user stories. The 13 criteria are divided into three different categories *Syntactic*, *Semantic* and *Pragmatic*, shown in Figure 9.

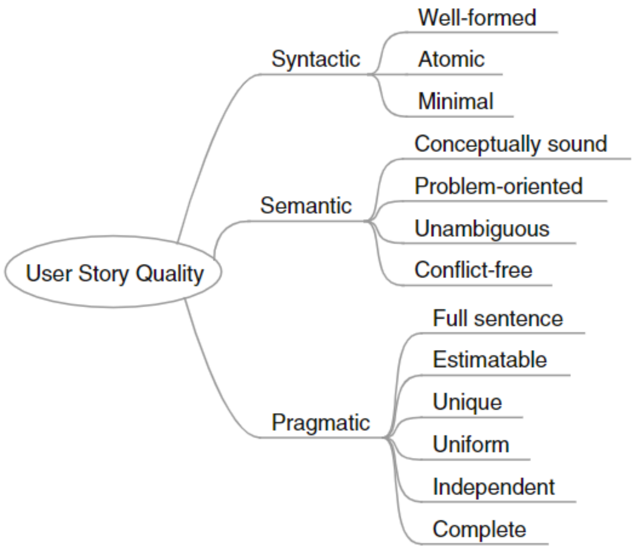

Figure 9. Schematic picture of QUS (Lucassen et al., 2016).

The first category, syntactic, includes Well-formed, Atomic, and Minimal. These three criteria focus on how user stories should be written, ensuring the correct syntax with role and meaning. Additionally, a user story should express only one feature and include the components: who, what, and why.

The second category, semantic, consists of four parts: Conceptual Sound, Problem-Oriented, Unambiguous, and Conflict-Free. Conceptual Sound means that the sentence should make sense. Problem-Oriented and Unambiguous means that the story should focus on a specific problem and avoid terms with multiple meanings. Additionally, the story should be Conflict-Free and contain only one user story.

The last category, pragmatic, consists of the criteria: Full Sentence, Estimable, Unique, Uniform, Independent, and Complete. The story should be written as a grammatically correct sentence and include enough detail for effort estimation. Additionally, it should be unique, follow a consistent format, be independent of other stories, and contain sufficient information for implementation.

2.5 Wireframing

To concretize user stories for tools or web pages, wireframing can be used. Wireframing is a method often used in computer science for website development and design (Sutipitakwong & Jamsri, 2020). Moreover, it is a commonly used method in computer science education and is an efficient way of sharing thoughts on design and functionality ideas. A wireframe is a sketch of a web interface including the core form and function for a website (Hamm, 2014). The development of a wireframe is made in stages where the wireframe increases in detail as it is refined. Figure 10 shows an example of an early-stage wireframe. This refinement is made in communication with the user in order to meet the goals of the project (Hamm, 2014).

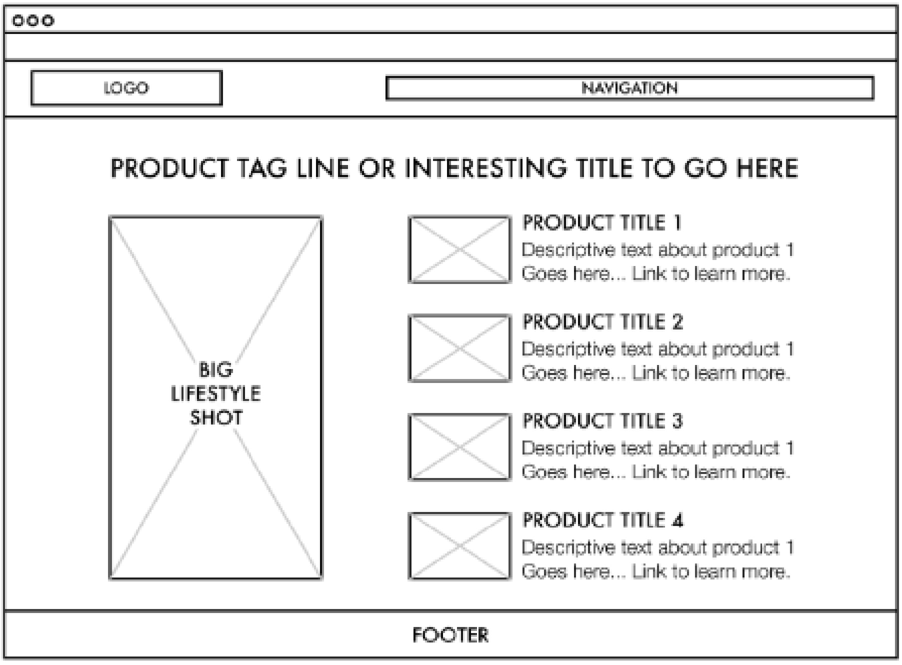

Figure 10. Example of a wireframe (Hamm, 2014).

The stages included in the development of a wireframe are creating a high-level map of the application, mapping the tasks for each page, defining the required content, validating and testing the design, refining the design, and documenting the UX patterns (Hamm, 2014). The first two stages focus on creating a task flow diagram to outline the system's functionalities. Once the task flow diagram is created, it can be transformed into a wireframe.

In the third stage, defining the required content, a first draft of the wireframe is created, as Figure 10, usually as a very basic sketch showing the included elements. Usually these elements are navigation, text, and graphics to give an overview of the design (Hamm, 2014). In the next stage, validating and testing the design, the wireframe is presented to the user to gather feedback.

This is followed by the refinement stage, where the design improved based on feedback. The refinement stage is a responsive process, where the wireframe is continuously revised and increasing in detail for each round. This includes the addition of more specific functions such as buttons, interactive elements, dropdown lists, links, and step indicators showing task flows (Hamm, 2014). Finally, the UX patterns of the wireframe are documented so the wireframe can be developed into a mock-up and eventually a working application.

3 Methodology

This chapter will explain the methodology used for this thesis, including the research approach and process as well as all methods used to develop a wireframe for the tool CO_2mpis. This thesis adopts an inductive approach, in which theories and patterns are developed based on data collected from fit-out projects. This bottom-up approach enables the development of theories grounded in empirical findings (Azungah, 2018). The inductive approach facilitates a deeper, contextual understanding of the topic and allows reflexivity and open-mindedness throughout the research process.

To support this, a combination of methods, including observations, interviews, data analysis and software tool development methods like user stories and wireframe, have been employed. Through these methods, both qualitative and quantitative research techniques were applied to provide a comprehensive exploration of the subject matter (Azungah, 2018).

3.1 Research Process

The research process for this thesis is divided into three main areas, consisting of the mapping of the fit-out process, the first research question, and the other two research questions. Each area includes specific objectives designed to address the research questions. The results from each area are then used to develop a wireframe for the tool CO_2mpis. The areas and objectives are presented in Figure 11.

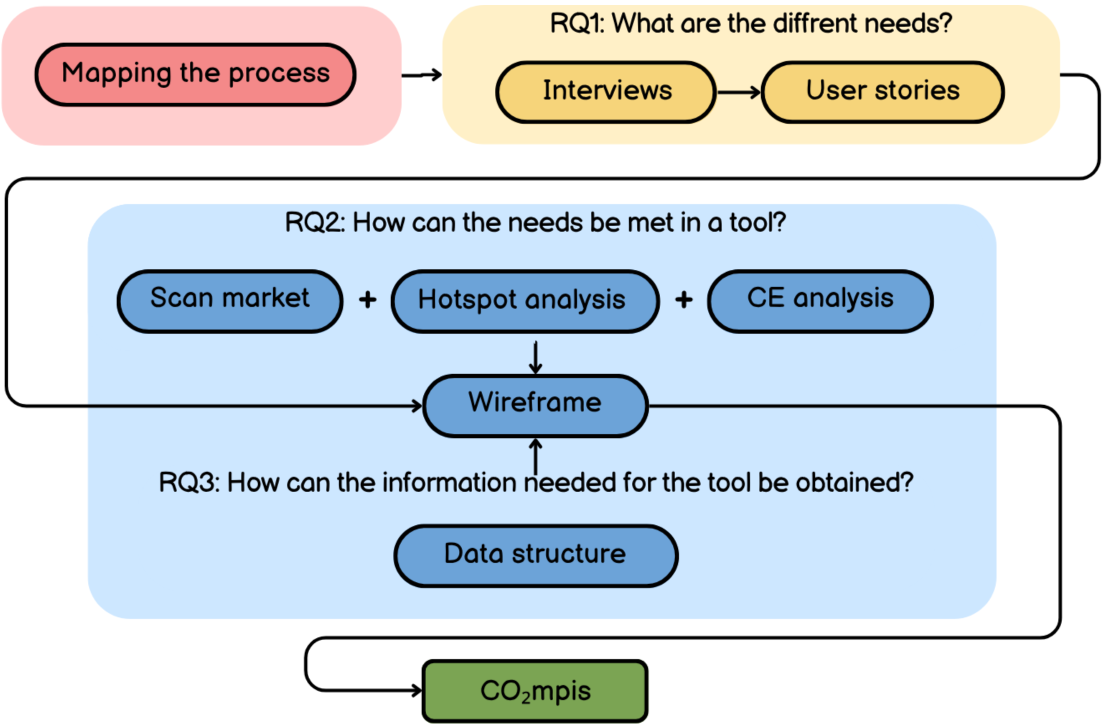

Figure 11. Research process.

The first area, red in the figure, involves mapping the current fit-out process at Vasakronan to gain a comprehensive understanding of the current practices. The second area, yellow, consists of an interview study with various actors at Vasakronan. The interviews were used to identify their needs and translate them into user stories. The third area, blue, focuses on the development of a wireframe, a method commonly used in web design, to illustrate how the proposed tool might look and function. To support the tool development, additional research was conducted including a market scan on existing tools, along with a CO_2 hotspot analysis and developing a circular economy (CE) framework. An additional step was included to map out relevant data sources and information pathways, to ensure effective integration into the tool. Finally, all the gathered information was used to develop the wireframe of CO_2mpis. Additionally, throughout the research process the AI tool ChatGPT was used to help with brainstorming ideas and structuring the work.

3.2 Mapping fit-out projects at Vasakronan

To gain an understanding of the fit-out process at Vasakronan, the current process was mapped using a Soft Systems Methodology (SSM) approach. More specifically, through the creation of a rich picture (Checkland, 2000). A rich picture is a technique that visually represents a system by combining text, symbols, arrows, and images to illustrate relationships and processes within a complex system (Midgley, 2015). The rich picture for the fit-out process at Vasakronan is shown in Figure 12.

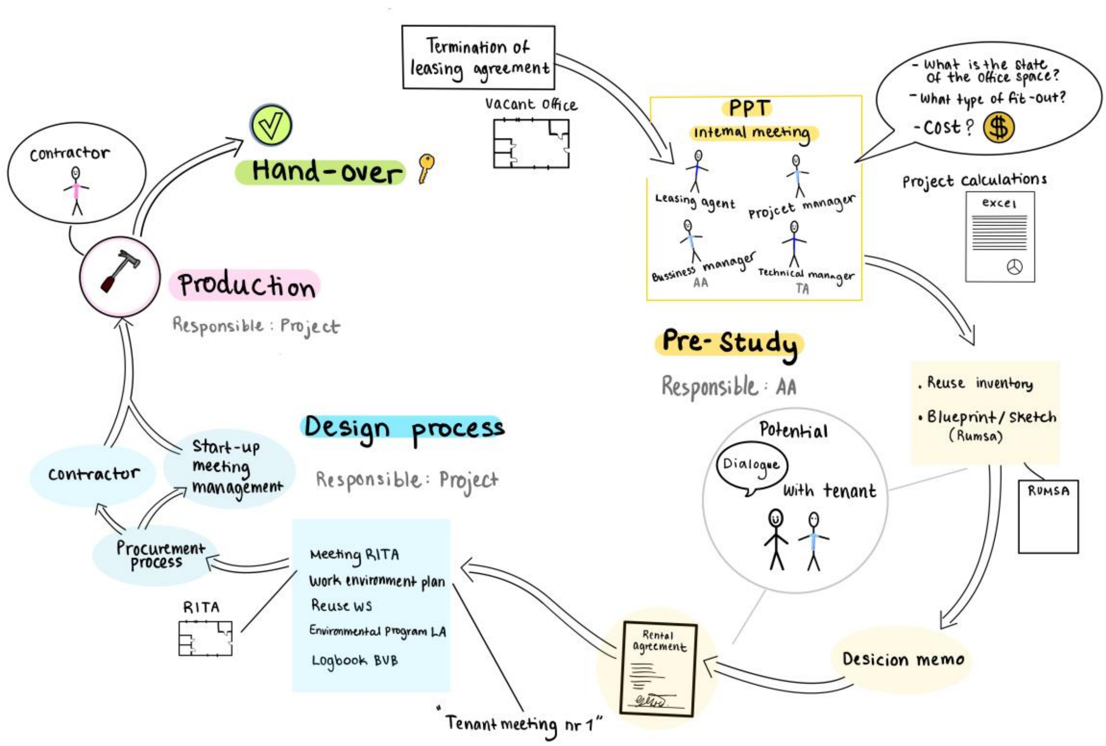

Figure 12. Rich picture of the fit-out process at Vasakronan.

To gather the necessary information for mapping the fit-out process, both observations and dialogues with Vasakronan were conducted. The first observation took place during a property showcase with the Leasing agent and a potential tenant, offering insights into the office space's condition prior to the fit-out. Additionally, the observation gave insights into the interactions and dialogue between potential tenants and the leasing agent, including expressed wishes and concerns.

The second observation occurred during a visit to an ongoing fit-out project, where a tenant meeting was attended. At the meeting a tenant and project manager were present. This observation focused on the communication between tenant and Vasakronan, with both parties' needs and concerns being noted. Furthermore, internal discussions with key actors at Vasakronan were held, and relevant documentation was gathered and reviewed to support the mapping process.

3.3 Understanding the needs

To understand the communication needs for a tool, various actors at Vasakronan were interviewed. These interviews provided valuable insights into the desired functionalities and the type of information required. The knowledge gained from the interviews was then used to create user stories, which served as a foundation in the wireframe design.

3.3.1 Interviews to understand the actors needs

To understand the different needs semi-structured interviews as defined by Alsaawi (2014) were conducted with different actors at Vasakronan. The interviews and questions were developed with help of the recommendations by (Alsaawi, 2014) where the interview is divided into five parts, Introduction, Warm-up, Main-body, Cool-off and Closure. Based on this method open-ended questions were developed, see Appendix A.

From the mapping of the fit-out process at Vasakronan three relevant actors that are part of the fit-out process at Vasakronan, the Project manager, Business manager and Leasing agent, were chosen. These specific roles were selected since they have contact with the tenant and have influence on material selection in projects. The Technical manager, also involved in the fit-out process, was not interviewed. The reason for this was that the Technical manager is responsible for the technical aspects of the fit-out and does not discuss material selection with the tenants. The interviews gave insights into the different actors' roles in the company, how they engage with tenants and how they could benefit from a tool. The table below shows the interviewees.

Table 2. Interviewed actors at Vasakronan.

Project manger	Project manager (PM) at Vasakronan, working with routine fit-out projects and have extra responsibility for reuse work.
Business manager	Business manager (BM) at Vasakronan, working with tenant relationship and strategies for office buildings.
Leasing agent	Leasing agent (LA) at Vasakronan, responsible for the rental process and maintains a close dialog with new clients.

The interviews were recorded, transcribed using the AI tool *Klang.AI* and then reviewed by the authors to ensure accuracy. With the help of the transcriptions the findings from the interviews were analyzed using the thematic coding approach

(Robson & McCartan, 2016). The approach includes five stages, familiarizing yourself with your data, generating initial codes, identifying themes, constructing thematic networks and integration and interpretation. This analysis was made by hand, and the following themes were identified: *Trends on the office market*, *challenges and opportunities for circular economy*, and the *actors' different needs*. Findings on the actors' different needs were used to formulate user stories.

3.3.2 User stories

Based on the analyses of the interviews, user stories were developed according to the Quality User Stories (QUS) framework by Lucassen et al. (2016), explained in chapter 2.4: User stories. The first step was to define the type of user, Project manager, Business manager or Leasing agent. After defining the user-type a goal was defined, the goal was expressed as needs articulated by the actors during interviews. To ensure the accuracy of the user stories they were checked by the interviewees themselves, and based on the feedback the user stories were refined. For example, the Project manager's user story was changed from *"accurately show CO2 emissions"* to *"pedagogically presents CO2 emissions"*. The specific needs and the reasons behind them were gathered from the summaries presented in chapter 4.1.3: The Actors' different needs. The user story for the Project manager was used to exemplify the design of the tool and its functionalities.

3.4 Tool Structure and Functionalities

After the actors' needs were defined, a wireframe for the tool was developed. To showcase the tool, wireframing was used to visualize the design and functionalities in a simple and clear format according to Hamm (2014). The method is further explained in chapter 2.5: Wireframing. Acquiring the essential information for the wireframe included scanning the market for other relevant tools, conducting a hotspot analysis on previous fit-outs at Vasakronan, and developing a circular economy framework. The gathered data and information were then used as a basis and complement to the user story in developing the tool.

3.4.1 Market Scan

Before developing a new tool, the market was first scanned to see if there were other tools on the market, already meeting Vasakronans needs. This included exploring tools and programs on the market used for material selection and for facilitating circular practices. For example, CIX was a tool identified used to facilitate circular construction (Östlund et al., 2020), which bears resemblance to what this thesis wants to achieve.

To identify tools, source engines and databases, including Google Scholar and Scopus, were used. To find relevant tools, key words like: *Circular economy, Circular material tools, Material tool, Fit-out, Office*, *Circular construction,* and C*ircular fit-outs* were used. Additionally, insights on tools used within the real estate sector were collected through dialogues with Vasakronan. This included tools Vasakronan currently uses or tools they have come across in their work. A general overview of tools supporting circular construction was gathered. The tools were then evaluated to see if they would assist in material selection in a Vasakronan fit-out project and their designs and functionalities assessed to provide insights on design for a tool.

3.4.2 Hotspot Analysis

To reduce CO_2 emissions from fit-out projects it is essential to identify hotspots, meaning the actions contributing to the largest emissions. To enable this, data was compiled from 7 previous fit-out projects. The data gathered was gained from project calculations, data sheets that are used in all fit-outs at Vasakronan. In this chapter, the method for identifying hotspots is described.

The data collected from the project calculations consisted of "actions" including "independent actions" and "modules". An "independent action" is for example, a suspended ceiling, wood floor or a door frame. They are singular actions that can be installed into the space. On the other hand, "modules" are pre-grouped actions, for example, Kitchenette Large and Bathroom-silicone based sealant.

Within the project calculations, the actions are divided into distinct categories. The Project manager selects and fills in the actions relevant to the project. The hotspot analysis was limited to the actions responsible for CO_2 emissions and therefore actions in the categories *Ceiling, Partition walls and doors, Floor, Kitchenette, Bathroom, Fire sealing and building supplements, Installations HVAC and STYR* and *Installations electricity and fire alarms* were analyzed.

The actions from the data sheets were compiled into one list. The actions responsible for 90 % of the emissions were then selected to be further investigated. This limitation was made to avoid spending time on actions with little or no effect on the overall emissions. Narrowing down the data also facilitates a more effective and manageable analysis (GHG Protocol, 2004). In this case 90 % of the emissions corresponded to 50 % of the total number of actions identified in the project calculations, making it a well-balanced limitation.

For this thesis, only actions relevant in communication with tenants were insightful. As a result, actions not relevant in communication such as installations and floor leveling were removed. The removed actions are necessary for the functioning of the space, if required, and are thereby not points of discussion during tenant meetings (A. Höjer, personal communication, March 28, 2025). The remaining actions were identified as hotspots.

Identified modules within the hotspots were further analyzed using diagrams. To enhance clarity and comprehension, modules within the same category (*Kitchenette* and *Bathroom*) were grouped to provide a more general overview. The diagrams visualized the independent actions within the modules and their respective emission shares.

3.4.3 Developing a Circular Economy framework

To relate circular economy (CE) to CO_2mpis, a framework was developed. To develop the framework other existing CE frameworks were analyzed. This was done to identify one that was adaptable to fit-out projects at Vasakronan and could be used to connect the tool to circular economy principles. To find relevant frameworks databases and key words like, *Circular economy, Frameworks*, *Strategies*, *Fit-outs*, *Circular building*, and *Circular construction* were used.

To determine if the framework was suitable for the tool a literature review was conducted, and three primary criteria were established to assess the relevance and applicability of the framework. Firstly, it was determined whether the framework was a circular economy framework, to ensure alignment with the purpose of the tool. Secondly, the legitimacy of the framework was evaluated, to see if it was developed by a credible source, such as industry bodies, academic institutions or established consultancy firms. Thirdly, the framework was assessed on if it was specifically developed for fit-out projects, ensuring relevance to the intended context. The framework that met all criteria, was used as a part of the CE framework for the tool. Furthermore, Vasakronans Reuse Hierarchy, presented in chapter 2.2.1: Material selection for fit-out projects at Vasakronan, was implemented in the framework.

3.4.4 Wireframe development

To show a visual representation of what CO_2mpis could look like, and its functionalities a wireframe for the project manager (PM) perspective was developed. The PMs user story, the market scan, the hotspot analysis and the circular economy framework provided the groundwork for the design and structure of the wireframe. This chapter will explain the steps in the wireframe development and how relevant data and information was connected to it.

The wireframe development can be divided into three steps. First, findings from the current process supported by the user story was implemented to the tool. Secondly, findings from the market scan were used to design the tool. Thirdly, data from the hotspot analysis and circular economy (CE) framework was added to the tool. In the current fit-out process the main way of selecting material is by using project calculations. The first step in developing the wireframe was to implement this data to the tool. Based on this, data from the project calculations was connected to the tool. Furthermore, the data served as the basepoint for the graphs and figures in the tool.

In the second step, insights from the market scan were used to design the wireframe. The tools from the market scan provided insights on interactive functionalities, and how data was displayed in a visual format. The insights were used as a basis for developing bars and graphs, similar to others found in tools on the market.

In the third step, data from the hotspot analysis was used to apply the right actions to the tool. Additionally, the emissions data were used to relate the emissions from the hotspots to plane trips. This was done by using general data on emissions factors and distances between different destinations. Emissions from planes were assumed to be 127 g CO_2e per person-km (Larsson & Månsson, 2024) and distances were obtained using Google maps. The emissions were then calculated by multiplying the emission factor with the distance. The calculations were compiled in an excel file and connected to the tool, see Appendix B.

To integrate CE principals into the tool a circular economy framework was implemented into the wireframe. This was made in two ways, as guidelines for the design and as strategies on materials. After a first version of the wireframe had been developed a meeting was held with the Project manager at Vasakronan to evaluate it. The thoughts and comments from Vasakronan were discussed and relevant input applied to the tool.

4 Result and Discussion

In this chapter the results of the thesis are presented and discussed. The results are structured based on the three research questions. First, the first research question, *What are the communication needs related to material selection for different actors at Vasakronan?* is addressed. Then, the second and third research questions, *How can a tool be designed to meet the specific needs of its intended users?* and *How can the necessary information for the tool's functionalities be collected?* are addressed.

4.1 Understanding the needs

This section presents and discusses the results for the first research question. This includes findings from the interviews and the user stories. Interviewing different actors in the process provided different insights into how a tool could be implemented and used. The Leasing agent (LA) and Business manager (BM) offered a market perspective by understanding the clients' needs. While the Project manager (PM) provided insights into how the fit-out process and material selection is carried out in more detail.

4.1.1 Market trends

To understand and facilitate the needs, the market and current trends are addressed. From the interviews some of the current trends that the interviewees have seen are a flight-to-quality trend and a request for smaller meeting rooms. According to one of the interviewees, having an appealing and newly built office has become increasingly important for many companies. The office can attract new employees and be a selling point from a company perspective. The BM said:

> *"There is a quite strong trend right now called "flight-to-quality". It means that tenants opt for newly developed office-spaces that feels new, fresh and has high quality." - BM*

This flight-to-quality trend is also identified by CBRE (2024). According to the BM, the higher demand for newly built offices has resulted in more vacant offices on the market. The increase in newly built real estate in Gothenburg and growing vacancies was also identified by Citymark (2024). Stating that the increase in real estate challenges secondary office areas. The BM provided an example, if a tenant is looking for a 300 sqm office there can be 50 vacant offices available, this allows the tenant to be selective in their office choice. This surplus leads to high competition between the real estate owners to gain a new tenant. As a result, this trend can force real estate companies to be more flexible with what they are willing to do in the fit-out project to secure a new tenant.

Another trend that the interviewees have seen after the pandemic is that the request for smaller meeting rooms in the office space has increased. This is a result of more meetings being held digitally, and therefore, smaller rooms for having these virtual meetings are needed. This leads to bigger changes in the layout of offices and the scope of a general fit-out increases. This trend cannot be confirmed for fit-outs, but it seems like a logical trend since there has been an increase in individual digital meetings as found by DeFilippis et al. (2022) post covid.

4.1.2 Challenges and opportunities

Several challenges and opportunities were identified by the interviewees to facilitate reductions in CO_2 emissions stemming from material use in fit-out projects. These challenges include aesthetic preferences, the “flight-to-quality” trend and lack of knowledge related to CO_2 emissions. The opportunities include a rising interest from tenants in working with sustainable materials and reporting according to the corporate sustainability reporting directive (CSRD). CSRD is connected to EU law that requires large companies to publish reports on how their activities impact the environment and people (European Union, n.d.).

The first barrier identified by the interviewees was aesthetics preferences. Many companies have visual guidelines, such as a set color palette or vision for all their offices. An example provided by the PM: a company has a specific orange carpet in all their offices. This is their brand color, and it makes it easy to “feel at home” in whichever office you might find yourself in. These aesthetic demands limit the potential for reused materials since a reused carpet might not be available in the specific color. An issue frequently occurring when designing with reused materials (Gorgolewski, 2008). Aesthetic requests like these are a way for companies to signal values to employees and contribute to the company image (Bille & Pilwind, 2023), which makes the flexibility in design, needed to adopt reused materials, more difficult.

> *“Design is probably the biggest hinder, from the tenant.” -PM*

> *“The clients are buying a product that is like a shell that you should fill with something that makes a good environment where you want to be, and it should be aesthetic. It should be both functional and aesthetic.” - LA*

According to the interviewees the aesthetics factor is one of the most significant obstacles for the tenants. Tenants often prioritize an attractive office space to attract employees. Which according to Sarabdeen et al. (2023) has become increasingly important resent years. These demands can hinder the implementation for circular practises in fit-outs.

Another challenge highlighted by the interviewees is the “flight-to-quality” trend, combined with a “buyers' market”. Where the supply of vacant offices exceeds the demand from clients (CBRE, 2024). This gives potential tenants an advance in negotiations and can make it even harder for the building owner to say no to tenants. There can be a hypothetical situation where the potential tenant says, either we install the orange carpet, or we choose another office. According to CBRE (2024), this market in turn puts pressure on the building owner. The owner either must compromise their climate ambitions or loose a tenant. Since the survival of the real estate company is reliant on rent from tenants, this can be a difficult situation in periods of economic difficulty.

Moreover, another barrier that the interviews revealed was the tenants lack of knowledge related to CO_2 emissions from materials. A common challenge is that the tenant doesn't understand the value of choosing a sustainable material, such as a reused one, which makes it difficult for Vasakronan to explain its’ advantages. This knowledge gap also means that the tenant may be unaware that they can request a sustainable fit-out with lower carbon emissions. This is in line with previous research, (Lundberg & Merhi, 2024) states that lack of knowledge is the biggest hinder in implementing reused materials. To overcome this hinder, there is a need for easy to understand and pedagogical material that can be used in communication with the tenant.

In addition to the barriers, opportunities were also discovered. When asked about the engagement from tenants in working with sustainable solutions and circular materials, there were some positive responses that emerged.

> *"It has become much better in the last couple of years. But it still varies from tenant to tenant." - PM*

> *"There is absolutely more engagement. Some have policy that their offices should be sustainably built, everything should be reused and reported according to CSRD... It has also become more common in the last couple of years for tenants to ask what has been done in a pre-lease fit-out before they move in." - BM*

These responses shows an increasing interest from tenants in working with sustainable materials. This increasing interest can be linked to the new demands from the European Union, such as the CSRD and the EU Taxonomy, which set requirements on companies for reporting impacts (European Union, n.d.). This increasing interest amongst tenants towards sustainability is something that GRESB (2019) has also identified. This leads to greater interest and knowledge in how companies can reduce their environmental impact and facilitates Vasakronans work in reducing emissions.

The interviews indicated that there exist both challenges and opportunities to reduce carbon emissions from material use in fit-outs. An interesting observation is that lack of knowledge exists alongside an increasing interest and awareness from tenants. This dynamic is seen as both a challenge and an opportunity, showing that fit-out contexts are changing and can vary depending on the tenant.

4.1.3 The actors' different needs

The actors at Vasakronan have varying needs and preferences for a tool and how to use it. Some of the needs that came up during the interviews include requests for visual communication in a tool and the ability to compare emissions with other CO_2 -intensive activities Furthermore, some kind of certificate for fit-outs, accessible information about the office space and examples from previous projects. The needs will be further explained below.

The Project manager requested a tool that can be used as a support in communication with the tenant. Preferably this communication support should include visual material, that is easy to understand and looks nice. Right now, Vasakronan only have project calculations that are technical and only contains numbers to show the CO_2 emissions. Their numerical format limits their usefulness in client communication. Instead, the PM requested graphs that shows emissions or nice pictures. Furthermore, it was requested that the tool could contain information about the benefit of choosing environmentally friendly materials and what the tenant can gain from it. For example, how much CO_2 that can be saved by choosing a certain material. Additionally, the PM talked about comparing the emissions from the fit-out with X round trips between Stockholm and Gothenburg.

Many of the needs and requests from the PM, are useful and effective ways of portraying data to communicate and engage tenants. Knaflic (2020) emphasizes that data presented in spreadsheets can be easily forgotten since it doesn't naturally stick in our minds. In contrast, as requested by the PM, using visual effects such as graphs and pictures is a more effective way to present data and make it more memorable.

The Business manager expresses a slightly similar need, with communication material that is easy to understand, even for someone with no knowledge about CO_2 emissions. It should be easy for the tenant to do the right thing, the BM said. In the interview, ways of showing CO_2 emissions were discussed. One idea was to compare it with other CO_2 -intensive activities, like flights. For example, 200 square meters of textile carpet can be compared to X trips to Spain. The BM also talked about having some kind of certificate for what has been done in a pre-lease office to show new tenants. The wish is to have a short conclusion of the fit-out, including a list of what has been done and why, a comparison of the chosen material (e.g., reused and new ones), and a drawing of the office with markings on what has been done and how much CO_2 has been saved. In accordance with this, Knaflic (2020) points to the fact that the design should be understood by people with varying technical skills. This is in accordance with the Business managers' wish for information that is easy to understand for a person with no previous knowledge on CO_2 emissions.

The Leasing agent requested clear and visual information that can be used in an easy way. It is important for the LA to have the right information about the office and to be able to inform the new client about possible modifications to the office space. Therefore, a tool that helps formulate arguments and selling points is needed. Furthermore, the LA requested the integration of visual examples into the tool. For instance, to provide picture examples of reused materials in previous projects. This could improve the willingness amongst clients to implement reused materials in their own fit-out. The needs from the LA differ from the other interviewees' needs. However, it includes visual materials which is similar to what Knaflic (2020) advocates.

Based on the interviews, there is a request of a "material tool" in multiple phases in the process. But generally, as early as possible in the process. This is because it is in the beginning of projects that many of the major decisions are made. Projects are generally more influenceable and flexible early in the process compared to later in the process (Kirkham, 2015b). With this in mind, it can be determined that the actors have a greater influence on the tenants' material selection early in the projects.

Furthermore, the interviews revealed that the three different actors have varying needs in a tool, however there were also many similarities. For example, all actors asked for information presented in a clear and easy format to follow, so that anyone can understand the information presented without prior knowledge. Especially the PM and the BM had similar wishes for the tool. For example, both requested visual presentation and comparisons of CO_2 emissions in the project. Moreover, they requested a presentation on how much CO_2 had been saved in the fit-out project. Another interesting note was that both of them provided an example of comparing the CO_2 emissions generated in the fit-out project to flight trips. The BM also had a specific request for a summary or certificate to provide to tenants after a pre-lease fit-out project. The actors need that stood out from the others was the Leasing agent. The

LA wanted possible modifications and examples of other projects or cases where reused materials had been implemented.

4.1.4 User stories

Based on the interviews, user stories for the different actors at Vasakronan were developed. The user stories are written according to the following format: "As a (type of user), I want (goal), so that (some reason)". For the Business manager two user stories were developed since the Business manager requested two types of functionalities. The user stories can be seen in Table 3 below:

Table 3. User stories for the different actors at Vasakronan.

Project manager (PM)	As a **project manager**, I want a **simple and visual communication tool** that pedagogically presents and compares **CO2 emissions** and **savings** using **charts and images**, so that I can explain the environmental impact of materials to **tenants in a popular science format**.
Business manager (BM)	As a **Business manager**, I want **communication material** that is simple and easy to understand, by **comparing with other CO2-intensive activities**, like flights so I can communicate better with tenants with no prior knowledge of CO2 emissions.
Business manager (BM)	As a **Business manager**, I want a **fit-out certificate** summarizing the fit-out work, **including a list of actions, CO2 savings** and **a drawing marking changes**, so that I can show new tenants the savings in emissions and choices made during the fit-out.
Leasing Agent (LA)	As a **Leasing agent**, I want **a tool** that provides **clear information about office spaces, possible modification** and **examples of where reused materials have been implemented**. So that I can formulate compelling arguments, highlight selling points and effectively inform new clients during the leasing process.

The formulated user stories condense the knowledge gained in the interviews to shorter more direct paragraphs. They pay special attention to the actors' needs to truly specify their goals and the reason behind them in order to make their wishes clear. This allows for easier development of a tool since the needs are clearly stated (Lucassen et al., 2016).

To exemplify the design and functionalities of the tool the thesis focused on one of the three user stories. The actor chosen to focus on in the wireframe was the Project manager (PM), the reason behind this was partly because many overlaps between the PM and the BM were found. Such as their wish for presenting the data in an easy, visual and pedagogical format and to show CO2 savings. Furthermore, the PM has the strongest connection to material selection and is thereby the most relevant perspective to present.

4.2 Tool Structure and Functionalities

This chapter presents and discusses the findings answering RQ2 and RQ3, *How can a tool be designed to meet the specific needs of its intended users?* and *How can the necessary information for the tool's functionalities be collected?* This includes the findings from the market scan, Hotspot analysis, and circular economy (CE) framework development as well as the wireframe of the tool CO_2mpis.

4.2.1 Market scan

The findings from the market scanning are shown in Table 4 below. The table presents the different tools identified during the market scan, along with a brief description of each tool. The different tools are then discussed and compared to each other.

Table 4. Tools facilitating circular practices in construction.

Tool	Explanation	Source
CIX	An interactive platform that supports material selection and circular practices in construction. Evaluates the circularity of buildings and calculates a Circularity Index. To use the tool, users need to import project-specific data.	(CIX, n.d.)
Madaster	Interactive platform that supports documentation, management and analysis of material flows of building components. Users can upload building data on the platform and receive material passports, circularity indicators and data for asset management.	(Madaster, 2025)
Building Circularity Tool	Interactive platform tool that assesses and improves circularity in buildings by evaluating materials and designs. Based on the user's data input the tool provides circularity scores.	(One Click LCA, 2025)
CCBuild	Interactive platform that provides tools that supports circular construction inc. marketplace for reuse materials and logbook tool for material documentation.	(CCBuild, n.d.)
Circularity Dashboard	Interactive visualization tool that visualizes circularity indicators on a city level.	(CIRCuIT, 2020)

As the results show, there are tools that adapt some of the functionalities the Project manager at Vasakronan needs in the tool. For example, the CIX platform provides a simplified way of showing circularity in a building, see Figure 13 (CIX, n.d.). Which aligns with the user story for the Project manager by offering simple and visual communication. However, the user needs to import the data themselves (CIX, n.d.), and it is not possible to change material in an easy way and show the impact of specific choices. To efficiently compare different alternatives already existing materials or database inputs are needed.

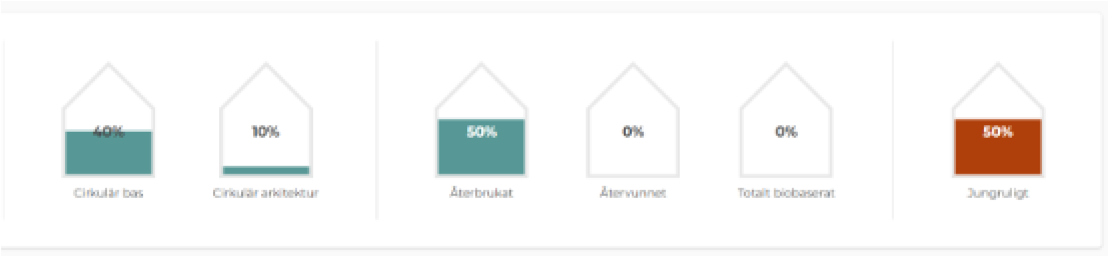

Figure 13. Interface of CIX, (CIX, n.d.).

Both Madaster and the Building Circularity Toolkit primarily assess circularity and do not fully support the material selection process (Madaster, 2025; One Click LCA, 2025). Although, they could still provide valuable insights on how to develop a tool and provide inspiration. These tools do, as CIX, require the user to import the project data themself and do not provide already existing materials (CIX, n.d.). In Figure 14 the designs for Madaster are shown, similar to CIX, Madaster has a simple design but includes more numbers and graphs.

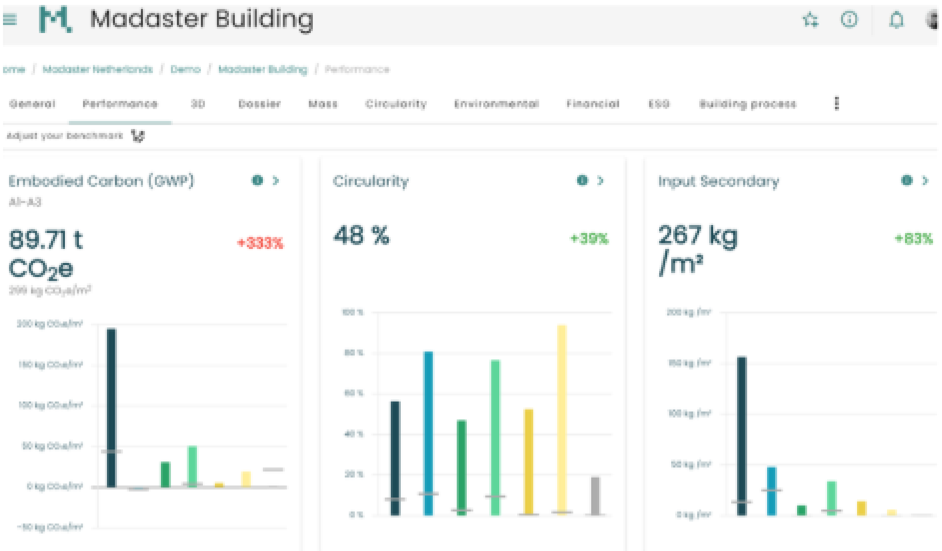

Figure 14. Interface from Madaster (Madaster, 2025).

CCBuild supports circularity by offering a marketplace and logbook that different stakeholders in the construction sector can use (CCBuild, n.d.). However, it does not fully support material selection or communication with tenants yet could be a good plug-in to the tool to get live information on available reused materials. This could be beneficial in relationships with tenants, offering real-world examples.

The Circularity Dashboard differs from the other tools since it is used on a city level and not on a building level (CIRCuIT, 2020). An example of a circularity dashboard for Hamburg are shown in Figure 15. The dashboard focuses on the amount of waste generated from construction and demolition and assesses circularity on a city level.

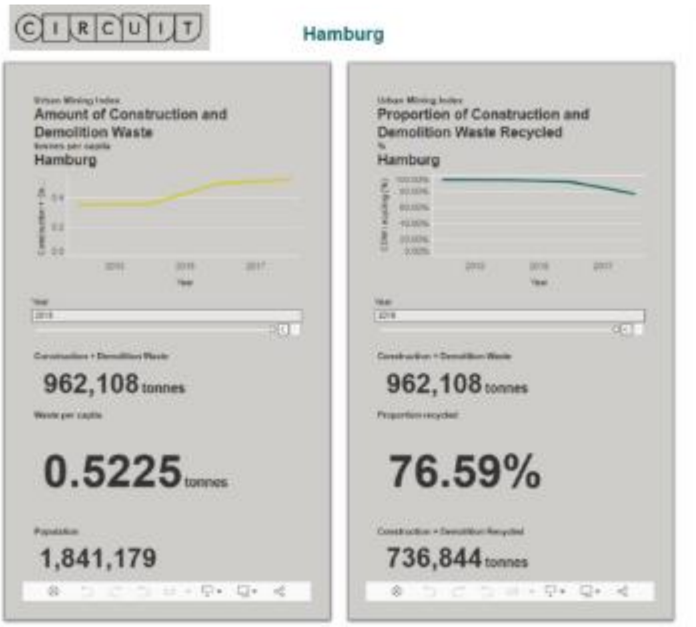

Figure 15. Interface for CIRCuIT (CIRCuIT, 2020).

The tools analyzed in the market scan support circular economy principles and strategies in construction on a building or city level. Still, none of them are specific for fit-out projects or supports the function of comparing different materials. The different tools give good insight on how a tool for fit-outs can be developed and will be used for inspiration. Once the market had been scanned the next step is to determine the fit-out actions responsible for the largest emissions.

4.2.2 Hotspot Analysis

Since the aim of this thesis is to facilitate the reduction of CO_2 emissions in Vasakronans fit-out projects, it is essential to identify the actions responsible for the highest emissions. By targeting these, the most significant emission reductions can be achieved. In this chapter, the hotspot analysis of fit-out projects at Vasakronan will be presented.

All actions in the 7 fit-out projects were complied, as can be seen in Table 5 below. The grey actions are modules, and the rest are independent actions. To narrow down the data and find the hotspots, the actions responsible for 90 % of the total emissions are investigated further. These are marked in yellow in Table 5. A more extensive table of all actions, including independent actions within modules, can be found in Appendix D.

Table 5. All actions including modules, marked in gray, listed. The actions marked in yellow represent 90% of all emissions generated in fit out projects.

Actions	Total CO2/ fit-out	% of CO2
Template value VS	10010	13.73%
Textile flooring	7824	10.74%
Template value ventilation	5320	7.30%
Template value electrical	4809	6.60%
Template value lighting	4462	6.12%
Door frame	3366	4.62%
Suspended cealing	2889	3.96%
Tiled wall	2413	3.31%
Kitchenette , large	2315	3.18%
Glass door - aluminum frame	2136	2.93%
Bathroom - Silicone-based sealant	2067	2.84%
Tamplate value STYR	1968	2.70%
Accessible bathroom- Silicone-based sealant	1916	2.63%
Basic bathroom Renovation	1746	2.40%
Partition wall - Steel 44 Rw (dB)	1744	2.39%
Modular wall - Glass, aluminium frame	1702	2.34%
Ceramic tile floor	1693	2.32%
Wood floor	1526	2.09%
Sprinkler system - templete value	1492	2.05%
Floor leveling, 1 cm	1453	1.99%
Kitchenette , small	1157	1.59%
Partition wall - Steel 35 Rw (dB)	1119	1.53%
Coffee station	999	1.37%
Acoustic panels	962	1.32%
Textile flooring > 50% recycled	884	1.21%
Microwavve	740	1.02%
Windowsills adjustment	650	0.89%
Refrigerator	582	0.80%
Paint walls	554	0.76%
Linoleum floor	515	0.71%
Bathroom Renovation inc. ceramics	511	0.70%
Dishwasher	393	0.54%
Template value fire alarm	252	0.35%
Modular wall - MDF	213	0.29%
Fire sealing, board	136	0.19%
Renovation kitchenette simple	126	0.17%
Modular wall - Gipsum	78	0.11%
Interior door - wood	55	0.08%
Fire sealing, foam	27	0.04%
Paint suspended ceiling	25	0.03%
Innerdoor - wood and fireresistant	18	0.02%
LED, armarure	15	0.02%
Countertop	12	0.02%
Building supplement exsisting walls	10	0.01%

In addition to limiting the data to actions responsible for 90 % of emissions, another limitation was made based on relevance in communication with tenants. Relevance refers to whether the action is something that causes discussion between Vasakronan and the tenant during material selection. For instance, materials for installations, such as ventilation systems and fire alarms, are typically not a big discussion with the tenant.

The results from narrowing down the data are shown in Table 6. The actions are grouped into the following categories: *Floor*, *Partition walls and door*, *Kitchenette*, *Ceiling*, and *Bathroom.* Based on the categorization in Vasakronans project calculations. These actions are the hotspots that Vasakronan should focus on in fit-out projects and will lay the foundation for the tool's functionalities.

Table 6. Hotspots from the fit-out projects including CO2 emissions.

Categories	Action	Unit	kg CO2/ unit	Total CO2/ fit-out
Floor	Textile flooring	m^2	17	7824
	Wood floor	m^2	7.5	1526
	Ceramic tile floor	m^2	19	1693
Partition walls and Doors	Door frame	pcs	252	3366
	Glass door - aluminum frame	pcs	152	2136
	Modular wall - Glass, aluminium frame	m^2	44	1702
	Partition wall - Steel 35 Rw (dB)	m^2	9.7	1119
	Partition wall - Steel 44 Rw (dB)	m^2	9.7	1744
	Tiled wall	m^2	18	2413
Kitchenette	Kitchenette , large	pcs	2314	2315
	Kitchenette , small	pcs	1157	1157
	Coffee station	pcs	499	999
Ceiling	Suspended ceiling	m^2	4.5	2889
Bathroom	Bathroom - Silicone-based sealant	pcs	563	2067
	Accessible bathroom- Silicone-based sealant	pcs	1095	1916
	Basic bathroom Renovation	pcs	349	1746

The results from the hotspot analysis seem to be relevant from a replacement perspective. Once compared to the table by Svenska Miljöinstitutet (2021) presented in chapter 2.1: Fit-out projects, many of the independent action hotspots are frequently replaced. For instance, Textile carpets and Wood floors are replaced 75% of the time (75%). Inner doors (53%) and Glas panels (53%) are not replaced to the same extent, but still frequently. In addition, Ceiling panels (53%) are also quite often replaced. This means that there is a potential for reuse amongst these hotspot products and materials in the region.

As previously stated, the actions in the hotspot analysis consist of “independent actions” and “modules”. There are six different modules within the hotspots, these can be categorized into either Kitchenette or Bathroom. Into Kitchenette “Kitchenette large”, “Kitchenette small” and “Coffee station” are sorted. Into Bathroom “Bathroom-silicone based sealant”, “Accessible bathroom-silicone based sealant” and “Basic bathroom renovation” are sorted.

To provide an overview of the emission shares within the two categories, two diagrams are created. The diagrams present the average share of emissions for the modules by dividing the independent actions into categories. See the diagrams in Figure 16 and 17 below.

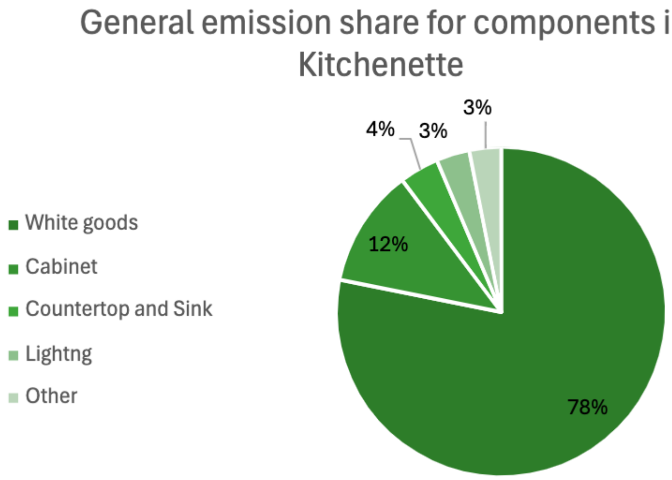

Figure 16. General emission share for Kitchenette.

In Figure 16 the individual actions in the kitchenette modules, “Kitchenette large”, “Kitchenette small” and “Coffee station”, are grouped into five categories: White goods, Cabinet, Countertop, Lightning and Other. The categories were made based on material content, similar to (FIRA, 2011) White goods include fridge, microwave and dishwasher. Cabinet covers all cabinetry, while Countertop contains the tap and sink with drain and trap. Lighting refers to the installed light, and Other include backsplash and sealant. In the diagram it is clear that White goods stand for the highest share of CO2 emissions in the Kitchenette modules. The most efficient way to reduce those emissions would be to use fewer white goods or to use reused ones. According to Vasakronan having fewer, for example microwaves are not relevant since the tenant don't want more microwaves than what is necessary. In addition, there can be resistance from the tenant for using reused white goods since they are responsible for the guarantee (A. Höjer, personal communication, 28 March 2025).

The largest shares in the Kitchenette diagram have similarities to the frequency of replacement table by Svenska Miljöinstitutet (2021) presented in chapter 2.1: Fit-out projects. Whitegoods such as refrigerator/freezers (are replaced 53% of the time), Dishwashers (53%) and microwave (53%). Furthermore, cabinet frames (53%), cabinet doors (75%). Finally, Countertops (75%) and sink units (53%). This means that the hotspots identified at Vasakronan are also frequently replaced in general fit-outs in the Gothenburg region.

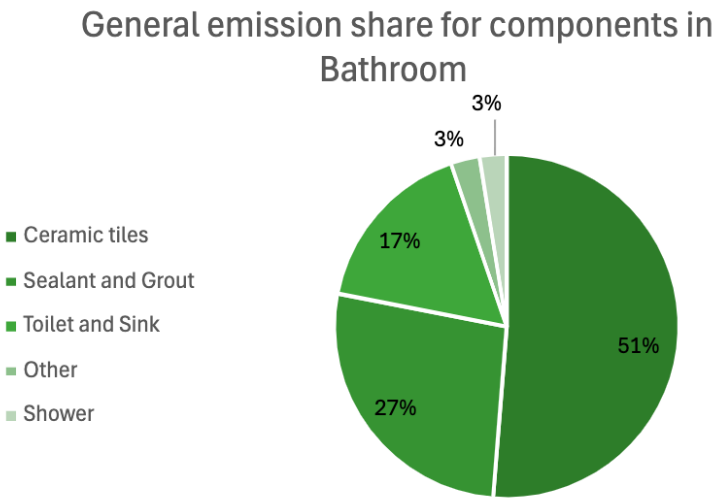

Figure 17. General emission share for Bathroom.

In Figure 17 the independent actions in the bathroom modules, "Bathroom-silicone based sealant", "Accessible bathroom-silicone based sealant" and "Basic bathroom renovation", are also grouped into five categories: Ceramic tiles, Sealant, Toilet and Sink, Other and Shower. The categories were made based on the material in components. In Toilet and Sink the toilet seat and sink are included, along with the armrest, washbasin tap and trap. Other includes floor leveling and mirror, while Shower consists of shower glass wall and mixer. As shown in Figure 17 Ceramic tiles, Sealant and Grout, and Toilet and Sink stands for the highest emissions in the bathroom modules. One way to reduce those emissions could be by using less material. For example, instead of tiling the entire wall, only tile a part of it.

Some of the shares in the Bathroom diagram also have some similarities to the frequency of replacement table by Svenska Miljöinstitutet (2021) presented in chapter 2.1: Fit-out projects. Toilet seat (45%), Sink and tap (45%), shower tap (53%). Seeing that many of the identified hotspot actions could be identified in Svenska Miljöinstitutet (2021) frequently replaced implies great possibilities for these hotspots to be reused. According to Svenska Miljöinstitutet (2021), it is deemed that only 10% of the replaced products cannot be reused, this means that 90% of products have potential for reuse. This in turn could drastically reduce carbon emissions stemming from fit-outs since many of these products are significant hotspots for CO_2 emissions.

The modules are different from the independent actions in the project calculations. While the independent actions are specific and can be modified on a detailed level the modules are harder to modify. The reason why Vasakronan is having these modules is to facilitate the project calculations and minimize the possibility of missing any components in the specific room modules. Because of this the modules and independent actions will be treated differently in the wireframe.

4.2.3 Circular Economy for fit-outs

Circular fit-out in retail stores by Arup (2022) is the Circular economy framework determined to be most compatible with Vasakronans fit-out projects. The framework is created for fit-out projects, and whilst being developed for retail stores, the principles presented are also applicable to office spaces. However, the framework places a strong emphasis on new materials, with limited attention given to materials already present in the space. To address this and connect the tool to Vasakronan, parts of Vasakronan's Reuse Hierarchy were incorporated to provide circular economy strategies for existing materials. This division between existing materials (Floorplan) and new materials (Materials) makes it most logical to structure the tool around these two areas.

For floorplan, guidelines based on Vasakronan's Reuse Hierarchy are developed, the hierarchy is further explained in chapter 2.2: The fit-out process at Vasakronan. The guidelines can be seen in the top row of Table 7 below. They are organized in a hierarchical order for managing the existing space and floorplan. To complement the steps and support their intended purpose, guiding questions are formulated, as shown in row 2 of Table 7 below.

Table 7. guidelines on design for full floor plan.

1. Reuse within floor plan and avoid new components	2. Reuse building components on-site	3. Reuse from another location
Can the existing floor plan and building components be kept?	*Can old products be fixed or used in a new way?*	*Can pre-used products be collected from other locations?*

The first guideline, Reuse within floor plan and avoid new components, highlights the potential of retaining the existing office space layout and minimizing the introduction of new components. It aligns with the first step of the reuse hierarchy and aligns with the current way of working at Vasakronan. The second guideline, Reuse building components on-site, promotes extending building components lifetime. This step relates to the second step of Vasakronans reuse hierarchy. It is achieved through repairing or repurposing components instead of allowing them to become waste. The third guideline aims to introduce more reused materials by collecting them from other locations. This guideline is related to the third step of the reuse hierarchy. These reused materials could come from other projects at Vasakronan or from external actors or platforms such as CCBuild (CCBuild, n.d.) or KlaraVik (Klaravik, n.d.).

In addition to being part of the tool, the guidelines could also be implemented and formulated to become a standard component within the PPT process for fit-outs. In the PPT process, the current state of the office space is evaluated. By applying the guidelines as a standard, assessing what can be retained or reused and sourcing additional reused materials, the PPT actively supports circular practices. The potential to influence the fit-out project is greatest in the early stages, which is why implementing guidelines at this point is highly beneficial (Kirkham, 2015b).

Materials is the second area and involves purchasing new materials for the space. Here strategies and principles from Arup's *Circular fit-out in retail stores* are applied. More background on the framework can be found in chapter 2.3.2: Circular fit-out in retail stores. The framework includes the 9R strategies, presented in chapter 2.3.1. Connected to the R-strategies the framework also includes circular principles.
The R-strategies and related principles are used in the tool to provide CE directives whilst selecting materials. An example of how the framework is used in the tool is

presented in Figure 18 below. In the pop-up box, directives related to Reuse presented in the framework are shown in a bullet point list.

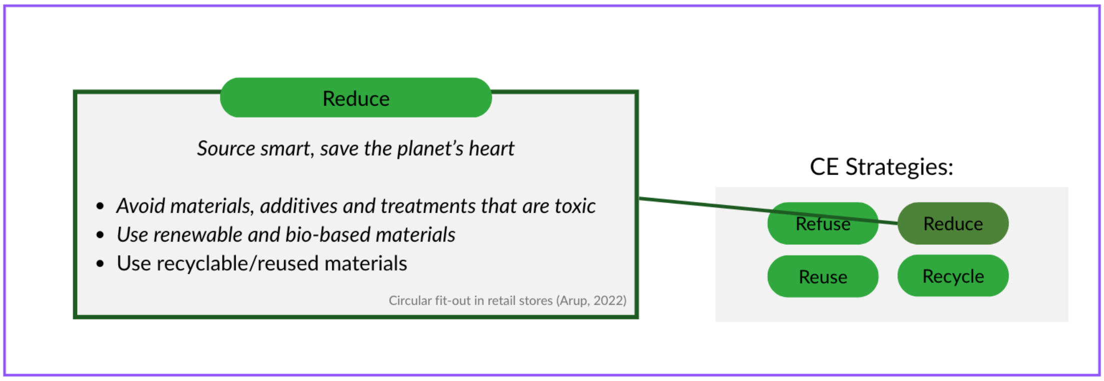

Figure 18. Example on how circular economy is applied to the tool.

4.2.4 Wireframe development

The wireframe for the tool CO_2mpis is developed to visualize the tool and explain its structure and functionalities. The Wireframe focuses on the needs expressed by the Project manager (PM) and is thereby based on the PMs user story. To visualize the expressed needs and translate them into functionalities capable of reducing CO_2 emissions, findings from the market scan, hotspot analysis, and circular economy framework are utilized.

In the current fit-out process the main way of selecting material is by using project calculations. Given that the project calculations are already used in the material selection process and contain a lot of useful data, the implementation of a tool in the project calculations or as a part of them would be preferable. Consequently, the tool that this thesis develops focuses on project calculations. However, the wireframe was developed based on that CO_2mpis as an independent tool. The most important functionalities of the wireframe are presented and discussed in this chapter. To see the wireframe in its full version, all frames included, see Appendix E.

The first step when opening the wireframe is to choose the user type, here it is possible to choose *Project manager*, *Business manager* or *Leasing agent*. If "Project manager" is chosen, it is possible to either continue with an existing CO_2 analysis project or to create a new one. If "Create new" is chosen, data about the project is imported from the project calculation. Information about the project is displayed, see

Figure 19, including project name, size and type of project. Information on the project type, building name and a picture of the building is added manually.

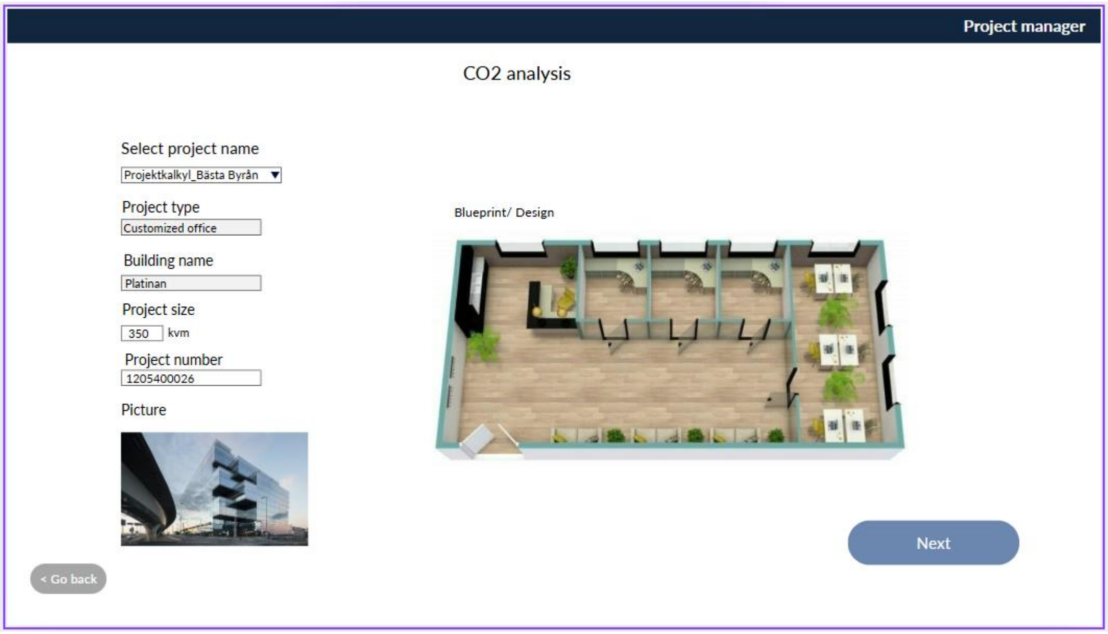

Figure 19. View when importing project.

This information is automatically filled in from the project calculation. The frame also includes a blueprint of the office to get an overview of the layout and components. The idea is that the blueprint is imported from the program RITA automatically connected to the tool. However, after conversation with Vasakronan this function seems to be several years away, since a connection between two programs like this can be complex and requires time to implement (A. Höjer, personal communication, May 5, 2025). However, the optimal approach is to include a blueprint, and the wireframe will thereby present the tools' functionalities using a blueprint.

When "Next" is clicked a menu will appear, see Figure 20 below. In the menu, the blueprint of the space and an overview of the project are presented. The menu serves as a hub, from which other tabs can be accessed. For example, the tabs "Full floor plan", "Materials" or "Report" can be selected to review and edit the project from various perspectives.

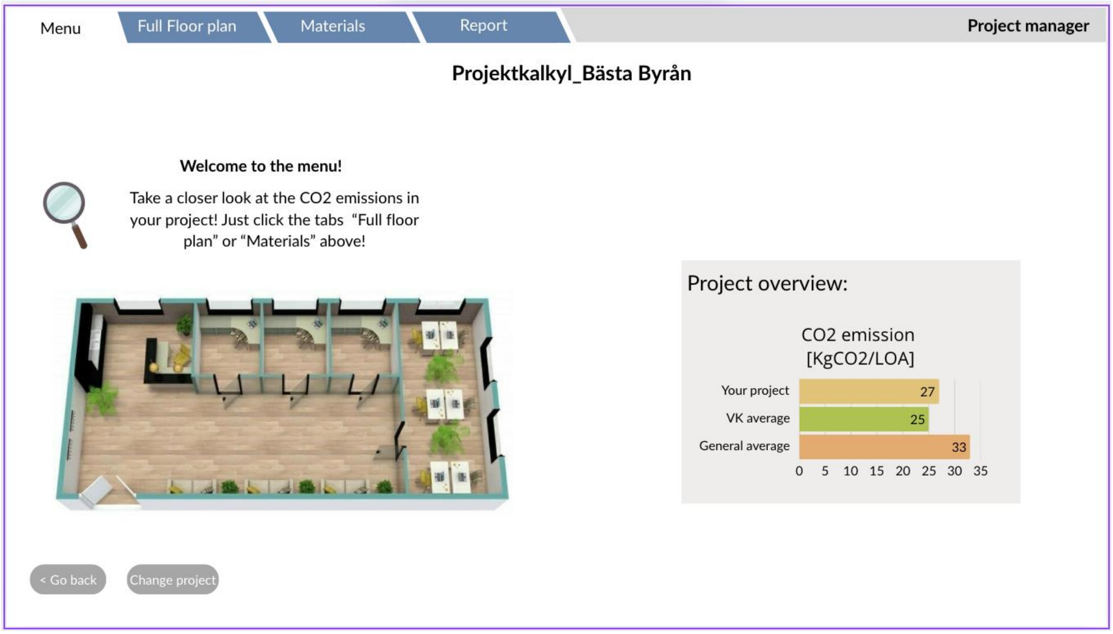

Figure 20. View when a new CO2 analysis has been created including project overview

In addition, a graph presenting a "project overview" is included. This addition was a result from refinement of the Wireframe, as Vasakronan requested a graph to compare the CO_2 emissions from the ongoing fit-out project to a Vasakronan average and a general market average. The data for the graph is partly gained from dialogue with Vasakronan, where it was learnt that their average emission for a fit-out project is around 25 kg CO_2e/ floor area. For the general average, AMF Fastigheter (n.d.) states that a general fit-out project emits 30-80 kg $CO_2e/m2$. In addition to this wide range, data from Vasakronan was used. Back in 2022 Vasakronans emission per floor area was 33 kg CO_2e, since Vasakronan has achieved substantial progress in lowering emissions (Hållbart Byggande, 2023), it is estimated that the general average emission per floorspace in a fit-out project is around 33 kg CO_2e. The resulting graph can be seen in Figure 20.

If the tab "Full floor plan" is selected, the frame below Figure 21, will appear. It presents guidelines associated with the already existing material in the office space, to avoid emissions. This includes the guidelines from the developed hierarchy explained in chapter 4.2.3: Circular economy for fit outs.

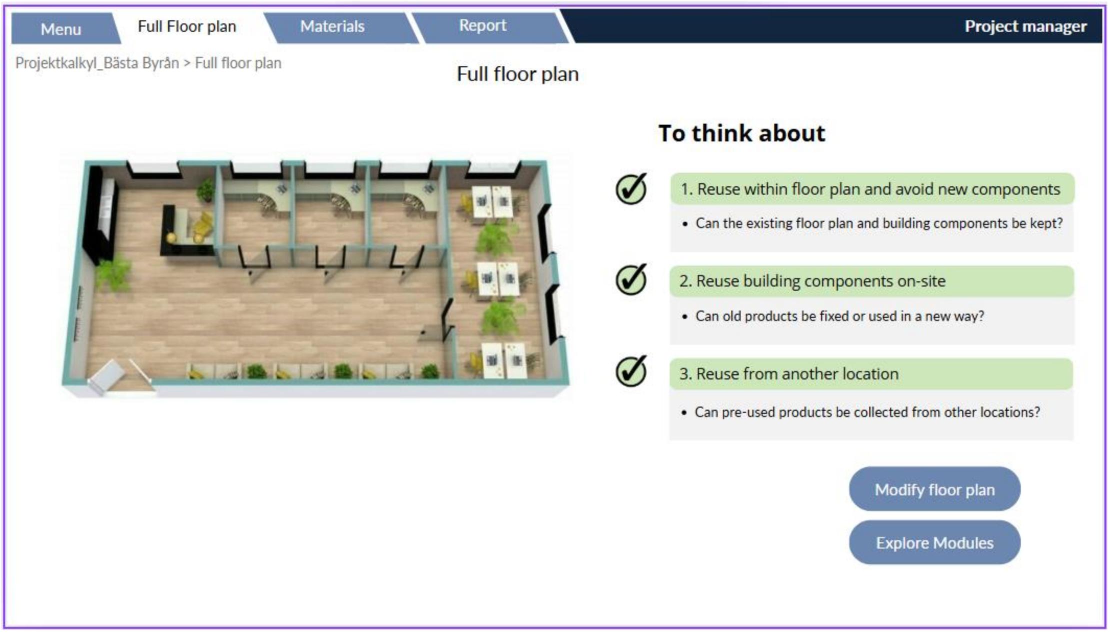

Figure 21. Full floor plan tab

In Figure 21 there are two buttons "Modify floor plan" and "Explore modules". If "Modify floor plan" is chosen, Figure 22 below will appear. In this figure the data from the project calculation is displayed, presenting the number of new rooms planned to construct and their related CO_2 emissions.

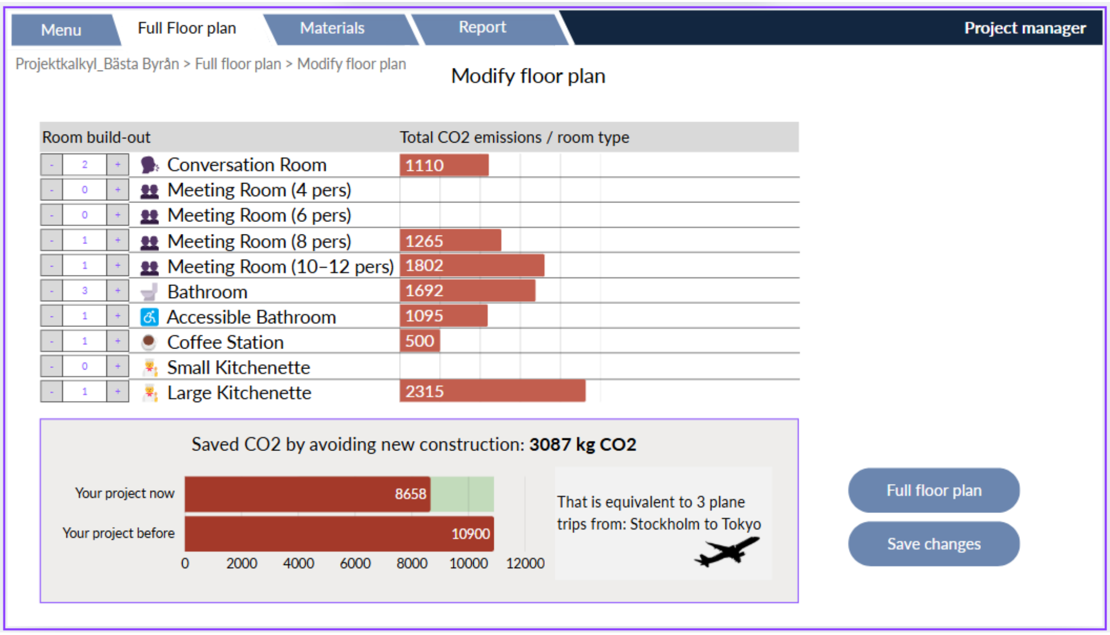

Figure 22. Modify floor plan

Here, it is possible to adjust the number of rooms to see how their construction, impacts the emissions compared to the original selection. The emissions are illustrated as two scenarios "Your project before" (original values) and "Your project now" (with your changes). The difference between the two scenarios is shown as X plane trips, in this case between Stockholm and Tokyo. The corresponding plane trips illustrating CO_2 savings are based on an excel list developed by the authors that can be seen in the Appendix B. The data behind the excel are based on general data on plane emissions and distances between different destinations, further explained in chapter 3.4.4: Wireframe development. Since the plane trip data can change, based on developed technology, a suggestion is that the data is checked every five years to see that the information remains correct and up to date. The button “Save changes” can be selected to save the alterations made to the floor plan. If the “Materials” tab is selected, specific materials can be taken a closer look at by selecting them from the blueprint. In Figure 23 below, the Textile floor is selected.

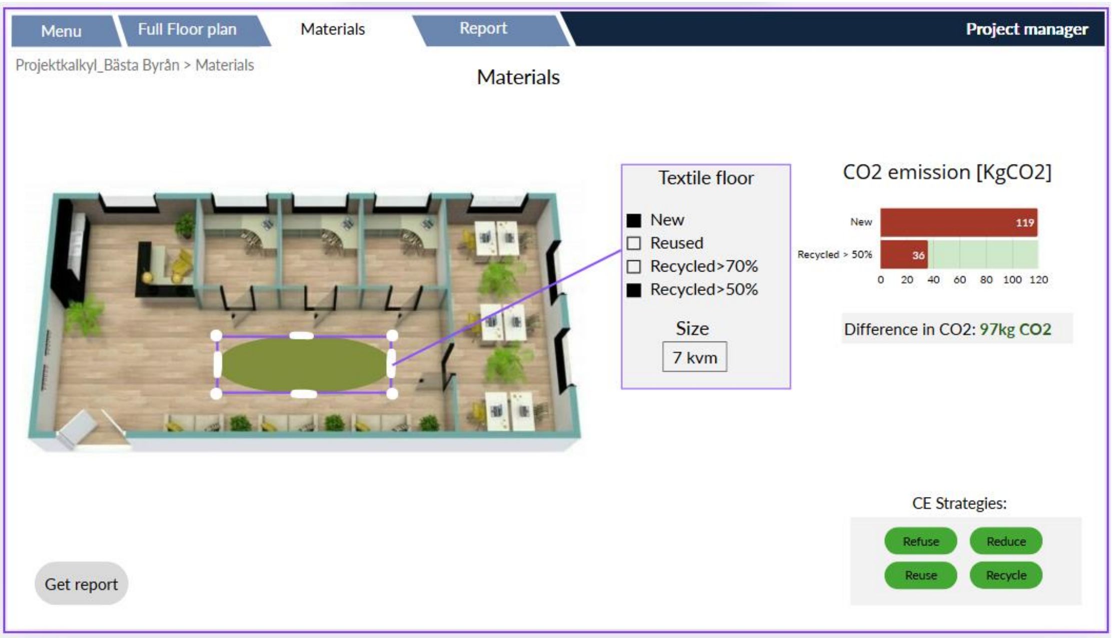

Figure 23. Comparing materials in this case textile floor.

When the material is selected, information about it is taken from the project calculation, in this example new textile floor “New”. The material can then be compared to other options, in this case a 50% recycled textile floor “Recycled >50%”. The option is selected by clicking the box and a comparison on the CO_2 emissions, and the related CO_2 savings will then appear. To select a new choice of textile floor the desired one is simply clicked one more and the black check box turns green, this can be made for all materials.

The data connected to the frame in Figure 23 can mainly be found in the project calculations data sheet. For example, to calculate the emission from the carpet the CO_2e per m2 carpet is multiplied by the carpet size m2 both of which can be obtained from the project calculation. For all materials CE strategies can be selected, see Figure 24 below.

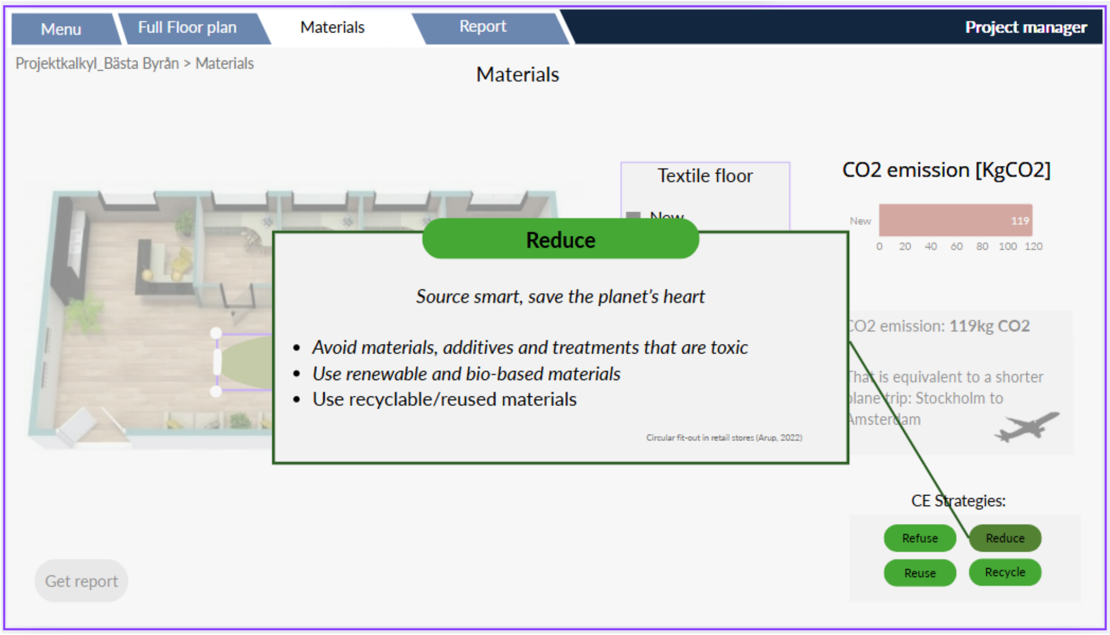

Figure 24. Showing the CE strategies in the tool.

If a CE strategy is selected, a pop-up window appears. The information presented contains information on the specific strategy including circular design principles. This information is taken from the framework *Circular fit-out in retail stores* by Arup (2022). The framework includes 10 strategies, after dialogue with Vasakronan, incorporating 10 strategies in the tool was deemed overwhelming for the tenant. Instead, only four of them were included in the tool to make the information easier for the tenant to understand. The four strategies are Refuse, Reduce, Reuse and Recycle. Their inclusion is based on insights from Vasakronan, reflecting the strategies they consider as most important in communication with tenants. In addition, three of the strategies Reduce, Reuse and Recycle are also included in the less extensive 3R framework (Vogiantzi & Tserpes, 2023). This suggests that they form a relevant grouping of strategies to include. The addition of the Refuse strategy is of significant importance, as it serves as a crucial first step in avoiding unnecessary new components.

When all modifications and material selections have been evaluated, the last tab "Report" can be chosen, as in Figure 25. The report presents a summary of the new material choices.

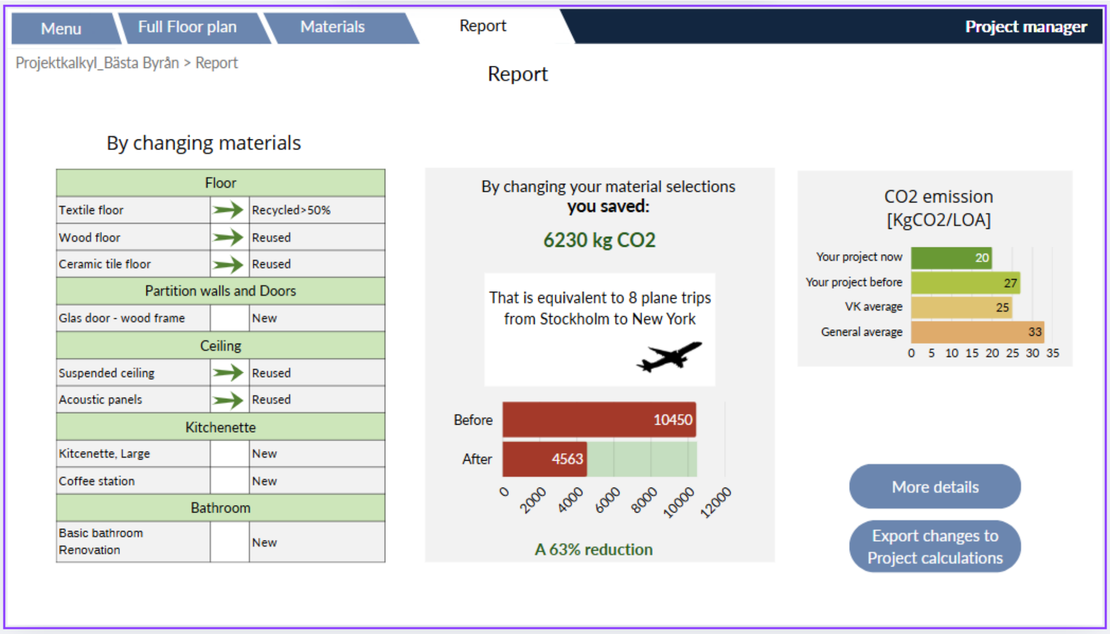

Figure 25. Report overview.

The green arrows show the change from the previously selected material to the new selections. Furthermore, a graph shows the total emissions generated from material selection in the fit-out. The data is taken from the project calculation sheet. The emission savings, achieved by changing materials, are shown as plane trips. If more detailed information on the changes made are wanted, the button "More details" can be pressed, see Figure 26.

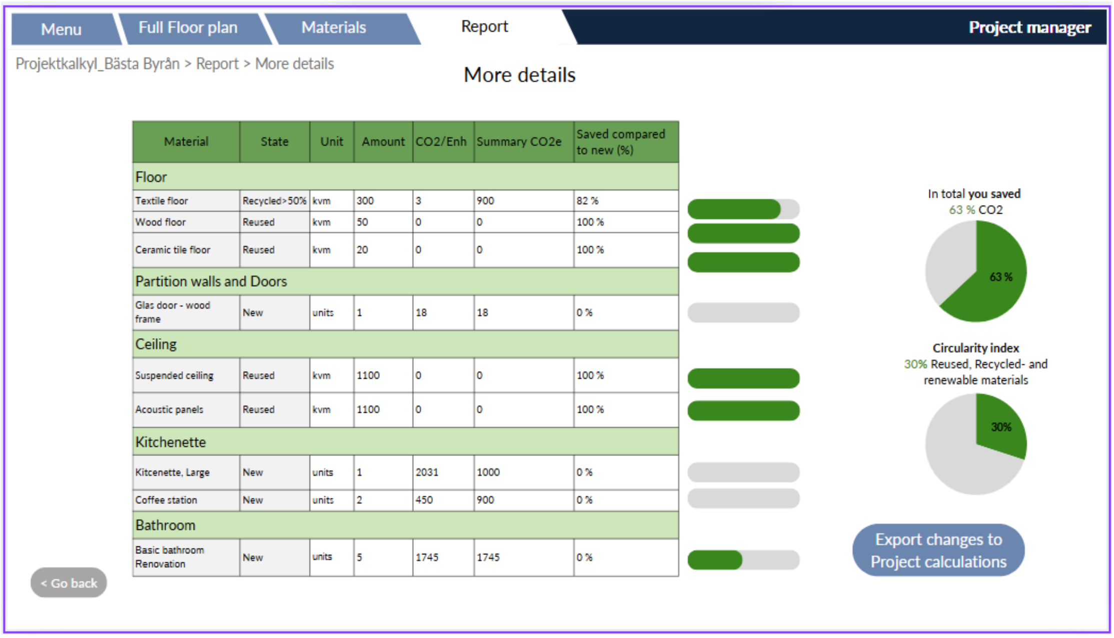

Figure 26. Report with total savings and Circularity index.

Here a summarized version of all actions is presented, with more details on the units, amounts and specific CO_2 data. Additionally, total savings and the Circularity index for the project are presented. The circularity index gives an overview of the amount of reused, recycled and renewable materials used in the fit-out project. This data can be saved and exported to the original project calculation.

5 Conclusion and Future work

This thesis aimed to facilitate the reduction of CO_2 emissions from fit-out projects by developing a wireframe for the tool CO_2mpis. This was done by evaluating the current fit-out process and understanding the needs from the different actors at Vasakronan. In this chapter, the main findings connected to the research questions and suggestions for future work will be presented.

RQ1: What are the communication needs related to material selection for different actors at Vasakronan?

It was concluded that a gap exists in the communication support available for material selection at Vasakronan. To bridge this gap, the actors at Vasakronan expressed a need for more visual support, including graphs and pictures. Furthermore, it was expressed that the support be formatted in a clear and simple way, so that the support is easy for a tenant with no prior knowledge to understand. Furthermore, functionalities like comparing CO_2 intensive actions were requested and to be able to visualize the impact of different material choices. Along the same lines, the ability to see CO_2 savings made, based on material choices was requested.

RQ2: How can a tool be designed to meet the specific needs of its intended users?

To meet the needs revealed through RQ1, the market was scanned for a suitable tool. As no existing solution was found, it was concluded that a new tool was necessary. This insight led to the development of the wireframe of the communication tool CO_2mpis, designed to help reduce emissions from fit-out projects and promote circular economy in fit-out projects. To create the visual support requested by the actors, it was concluded that data was needed to base the visualizations upon. This data was obtained through the hotspot analysis. The general hotspots identified in Vasakronans projects are as follows:

- Textile flooring
- Door frame
- Suspended ceiling
- Tiled wall
- Kitchenette
- Glass door
- Bathroom
- Interior wall
- Ceramic tile floor
- Wood floor

A finding related to the identified hotspots was that the hotspots correlate largely with IVLs identified often replaced materials. This means that there is a large opportunity for reuse amongst these highly emitting materials. Furthermore, it was requested by the actors to visualize CO2 savings and impacts, this was realized through incorporating plane trips to express emissions in a tangible format. To realize the aim of reducing emissions, circular economy was incorporated into the tool. A developed CE framework was incorporated to provide insights into CE strategies that can be applied to the fit-out project.

RQ3: How can the necessary information for the tool's functionalities be collected?

The data such as CO_2 emission from actions, needed for CO_2mpis are included in the project calculations. Information about CE practices was obtained from Arup's framework for fit-outs in retail stores and Vasakronans Reuse hierarchy. To visualize CO_2 emissions as plane trips, information was based on the sheet in Appendix B.

5.1 Future work

This thesis developed a wireframe for the tool CO_2mpis and identified the opportunity for a tool to reduce the CO_2 emission from fit-out projects at Vasakronan. The thesis identified several possibilities for future research.

Future work could involve developing the wireframe to become a working tool. Additionally, future work could test CO_2mpis in a real project to evaluate its usability and effectiveness to influence material decision. This testing can provide valuable feedback on how the CO_2mpis can be refined to be a more efficient tool. Other future work can focus on expanding CO_2mpis to not only investigate hotspots and include all actions in a fit-out. Future work could also include cost to the tool and show cost savings that can be made in relation to CO_2 emission savings. CO_2mpis is a tool developed in the context of Vasakronan, future work could explore if the tool can be applied to other companies.

The thesis identified a lack in Circular economy frameworks that could be easily applied to fit-out projects. Since the fit-outs are conducted frequently from a life cycle perspective, the support in having an easy-to-follow CE framework would be beneficial in guiding stakeholders during the fit-out process.

5.2 Reflection on the thesis

The development of the wireframe of CO_2mpis was not a straightforward process. Fit-outs involve a combination of technical, social, and economic factors. Their multifaced nature causes significant variation in size and scope, making it difficult to fit them into a streamlined process. Additionally, tenant needs and preferences meant that the project wasn't solely focused on a technical solution, social aspects had to be taken into account as well. Furthermore, constructing the wireframe for CO_2mpis was complex and can be compared to assembling a large puzzle. This complexity arose because the project incorporated several different methods including the hotspot analysis, interviews, market scan and CE framework.

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Appendix A

Interview questions:

1. Introduction

Our goal is to facilitate the implementation and use of circular materials, such as renewable, recycled, and reused materials, in office fit-out projects. We aim to develop a supporting tool that clarifies which processes contribute most to reducing carbon emissions and promoting more sustainable adaptations.

2. Warm-up

- What is your role at Vasakronan?
- What is your role in a fit-out project, and at what stage of the process are you involved?
    - When and how do you communicate with the tenant?

3. Main Body

- How does communication with tenants look during a fit-out?
    - Are there standardized meetings, workshops, emails, or other forms of dialogue?
- Is sustainability or material selection discussed with tenants?
    - Do you observe interest from tenants in sustainable solutions, such as reused materials?
    - Is there engagement from the tenants' side?
- At what stage would it be possible to introduce more sustainable options to the tenant?
- What kind of material or support would you wish for when communicating with the tenant?
    - Why would this be valuable?
    - What would this mean for increasing the use of circular materials in projects?
- Are there any examples where tenants have changed their choices after dialogue with Vasakronan?
- What obstacles do you see in influencing tenants' material choices or sustainability behaviors?
    - How could these obstacles be overcome?

4. Cool-off

- Do tenants receive information about how sustainable their fit-out is?
    - What does that information look like?

5. Closure

- Is there anything you would like to add or anything you think we may have missed that is important?

Appendix B

Plane trips:

Fylgresor		
Kommersiell flygresa: 0,1-0,2 kg CO2/km		
127 gram CO2-ekvival	https://klimatresa.se/data	
0.13	kg.CO2/p.Km	

Distance (km)	Tot. CO2 (kg)	Trip
1000	127.0	Stockholm - Amsterdam
1978	251.2	Stockholm - Rom
3400	431.8	Stockholm - Kairo
4589	582.8	Stockholm - Doha
4827	613.0	Stockholm - Abu Dhabi
5576	708.2	Stockholm - New Delhi
6319	802.5	Stockholm - New York
6640	843.3	Stockholm - Washington
8178	1038.6	Stockholm - Tokyo
8930	1134.1	Stockholm - Los Angeles
9645	1224.9	Stockholm - Singapore

Kg CO2	Flygresa
100	1 Resa Stockholm - Amsterdam
250	1 Resa Stockholm - Rom
500	2 Resor Stockholm - Rom
1000	4 Resor Stockholm - Rom
1500	6 Resor Stockholm - Rom
2000	8 Resor Stockholm - Rom
2500	10 Resor Stockholm - Rom
3000	3 Resor Stockolm - Tokyo
3500	8 Resor Stockholm - Kairo
4000	5 Resor Stockholm - New York
4500	4 Resor Stockolm - Tokyo
5000	4 Resor Stockholm - Singapore
5500	7 Resor Stockholm - New York
6000	5 Resor Stockholm - Singapore
6500	8 Resor Stockholm - New York
7000	7 Resor Stockholm - Tokyo
7500	6 Resor Stockholm - Singapore
8000	10 Resor Stockholm - New York
8500	7 Resor Stockholm - Singapore
9000	11 Resor Stockholm - New York
9500	9 Resor Stockholm - Tokyo
10000	8 Resor Stockholm - Singapore
10500	10 Resor Stockholm - Tokyo
11000	9 Resor Stockholm - Singapore

Appendix C

Project calculation:

Projektkalkyl
Version 5.0

Va

Datum		Projektnamn	Kst	Projekt nr	Underlag för kalkyl	
Rev.						

Inv.kod	Klassific.	Bygg	Inv. kod	Mängd	Summa kronor	Enh. - CO_2e
		LOA [kvm]	**0**	Mängd	Summa kronor	Enh. - CO_2e
					0	
		Demontering & Rivning	4135			
4135	%	Demontering WC	st		0	0
4135	%	Demontering pentry, stort	st		0	0
4135	%	Demontering pentry, litet	st		0	0
4135	%	Demontering vägg, skivvägg	kvm		0	0
4135	%	Demontering undertak	kvm		0	0
4135	%	Demontering golvbeläggning, ej limmad	kvm		0	0
4135	%	Rivning vägg, skivvägg	kvm		0	0
4135	%	Rivning vägg, tung vägg	kvm		0	0
4135	%	Rivning undertak	kvm		0	0
4135	%	Rivning golvbeläggning, klinker	kvm		0	0
4135	%	Rivning golvbeläggning, limmad	kvm		0	0
4135	%	Rivning golvbeläggning, ej limmad	kvm		0	0
4135	%	Rivning WC	st		0	0
4135	%	Rivning RWC	st		0	0
4135	%	Rivning pentry, stort	st		0	0
4135	%	Rivning pentry, litet	st		0	0
4135	%	Rivning dörr/parti	st		0	0
4135	%	Rivning El	st		0	0
4135	%	Rivning Vent/VVS	st		0	0
					0	0
		Återbruk	4140		**0**	
4140	3a	Akustikplattor	kvm		0	3
4140	3b	Modulvägg - Glas	kvm		0	45
4140	3b	Dörrportal	st		0	252
4140	3b	Platsbyggd vägg - Stålregel 35 Rw (dB)	kvm		0	10
4141	3b	Platsbyggd vägg - Stålregel 44 Rw (dB)	kvm		0	10
4140	3b	Lokalavskiljande vägg	kvm		0	59
4140	3b	Glasdörr - aluminiumram	st		0	153
4140	3b	Innerdörr - trä	st		0	7
4140	3b	Innerdörr - trä & brandklassad	st		0	18
4140	3b	Ståldörr	st		0	231
4140	3b	Invändigt entréparti av stål med sidoljus	st		0	0
4140	3a	Textilgolv	kvm		0	17
4140	3a	Trägolv	kvm		0	8
4140	3c	Pentry, stort	st		0	2 315
4140	3c	Pentry, litet	st		0	1 157
4140	3c	Kaffestation	st		0	500
4140	3a	WC beslagning	st		0	1
4140	3a	WC-sits	st		0	110
4140	3c	Kylbaffel	st		0	73
4140	3c	Don	st		0	1
4140	3c	LED, armatur	st		0	2
4140	3c	Elkabel	m		0	1
					0	
			Delsumma återbruk:		0	
4165		*Påslag på material tillhandahållet av VK*	%		0	
					0	
		Tak	4 140			
4140	3a	Måla undertak	kvm		0	0,5
4140	3c	Undertak	kvm		0	5
4140	3c	Akustikplattor	kvm		0	3
					0	
		Mellanväggar & Dörrar	4 140			
4140	3a	Måla väggar	kvm		0	0,5
4140	3b	Platsbyggd vägg - Stålregel 35 Rw (dB)	kvm		0	10

		Golv	4 140			
4140	3a	Textilgolv	kvm		0	17
4140	3a	Textilgolv > 50% återvunnet	kvm		0	4
4140	3a	Klinkergolv	kvm		0	18
4140	3a	Plastgolv	kvm		0	7
4140	3a	Linoleumgolv	kvm		0	4
4140	3a	Trägolv	kvm		0	8
4140	3a	Ångtvätt textilmatta	kvm		0	
4140	3a	Slipning	kvm		0	0
4140	3c	Golvavjämning, 1 cm	kvm.cm		0	4
					0	
		Pentry	4 140			
4140	3c	Pentry, stort	st		0	2 315
4140	3c	Pentry, litet	st		0	1 157
					0	
		WC	4 140			
4140	3c	WC - Silikonbaserad fog	st		0	564
4140	3c	RWC	st		0	1 095
4140	3c	Renovering WC Enkel	st		0	349
4140	3c	Renovering WC Inkl porslin	st		0	511
					0	
		Brandtätningar & Byggkompletering	4 140			
		Installationer VVS inkl styr			**0**	
4150	3c	Nyckeltal Ventilation	kvm		0	8
4160	3c	Nyckeltal VS	kvm		0	11
4159	3c	Nyckeltal Styr	kvm		0	6
4160	3c	Element st	st		0	115
4135	3c	Demonteringar	kvm		0	0
4150	3c	Injustering vent	st		0	0
4160	3c	Injustering rör	st		0	0
					0	
		Installationer el inkl. brandlarm			**0**	
4155	3c	Nyckeltal El	kvm		0	6
4183	3c	Nyckeltal Brandlarm	kvm		0	4
4182	3c	Sprinklersystem - nyckeltal sprinkler	st		0	4
4182	3c	Avstängningsventil (vridspjäll) - nyckeltal sprinl	st		0	0
4182	3c	Larmtablå - nyckeltal sprinkler	st		0	2
4182	3c	Injustering	st		0	0
4155	3c	Anpassning El	st		0	29
					0	
4155	3c	Nyckeltal Belysning	kvm		0	3
4155	3c	LED, panel	st		0	29
4155	3c	LED, armatur	st		0	2
					0	
			Delsumma produktion:		**0**	
		Avrundning			0	
					0	kr

Miljöuppgifter till Projektanmälan (Navigon)

CO2e-utsläpp, kg (A1-A5)	**0**
CO2e-utsläpp, kg (A1-A3)	**0**
CO2e-utsläpp, kg (A4)	**0**
CO2e-utsläpp, kg (A5)	**0**
Vikt nytt material, kg	**0**
Total vikt material, kg	**0**
Varav återvunnet, kg	**0**
Varav förnybart, kg	**0**
Varav återbrukat, kg	**0**
Cirkularitetsindex, %	**0**

Klassificering av investering enligt investeringskalkyl lokalanpassning

0

Dina tre byggmoduler med högst klimatpåverkan

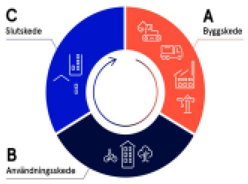
Övriga information

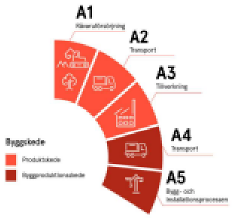
Kostnad/LOA (kr/kvm, inkl. moms)	**0**	
1:a CO2e-utsläpp per byggmodul	...	0
2:a CO2e-utsläpp per byggmodul	...	0
3:a CO2e-utsläpp per byggmodul	...	0
Återbruksindex (%)	0%	
Återbrukad CO2e-utsläpp, kg	0	

Klassificering av investering enligt investeringskalkyl lokalanpassning

3a. Ytskiktsrenovering	0
Resterande del av investering att fördela	0

Byggnadens livscykel





Kommentarer och förtydligande: Pris avser kostnader exkl. moms, inredning och utrustning

Simple project calculation:

Projektkalkyl "Enkel" version 3.0

Förenklad kalkyl (PPT-skede, mindre projekt)

Vasakronan

Projektnamn:			Datum:	Vem har räknat?
Projekt nr:				
Byggdel (Kategori)	**Enhet**	**Mängd**	**Summa kronor**	**Kommentar**
Bygg	Inv. kod		**0**	
Demontering & Rivning	4135			
Rivning/Demontering	kvm		0	
Återbruk	4140		**0**	
Moduler - Färdiga rum inklusive allt	4 140			
Samtalsrum	st		0	
Mötesrum 4 pers	st		0	
Mötesrum 6 pers	st		0	
Mötesrum 8 pers	st		0	
Mötesrum 10-12 pers	st		0	
WC	st		0	
RWC	st		0	
Kaffestation	st		0	
Pentry, litet	st		0	
Pentry, stort	st		0	
Golv	4 140			
Textilgolv > 50% återvunnet	kvm		0	
Klinkergolv	kvm		0	
Linoleumgolv	kvm		0	
Trägolv	kvm		0	
Ångtvätt textilmatta	kvm		0	
Slipning	kvm		0	
Golvavjämning, 1 cm	kvm.cm		0	
Komplettering bygg	4 140			
Undertak	kvm		0	
Platsbyggd vägg - Stålregel 44 Rw (dB)	kvm		0	
Måla väggar	kvm LOA		0	
Modulvägg - Glas, aluminiumram	kvm		0	
Invändigt entréparti av stål	st		0	
Dörrportal	st		0	
Glasdörr - träram	st		0	
Innerdörr - trä & brandklassad	st		0	
Bänkskiva	st		0	
Installationer			**0**	
Nyckeltal Ventilation	kvm		0	
Nyckeltal Styr	kvm		0	
Injustering vent	st		0	
Nyckeltal Belysning	kvm		0	
Nyckeltal El	kvm		0	
Sprinklersystem - nyckeltal sprinkler	kvm		0	
Nyckeltal Brandlarm	kvm		0	

Appendix D

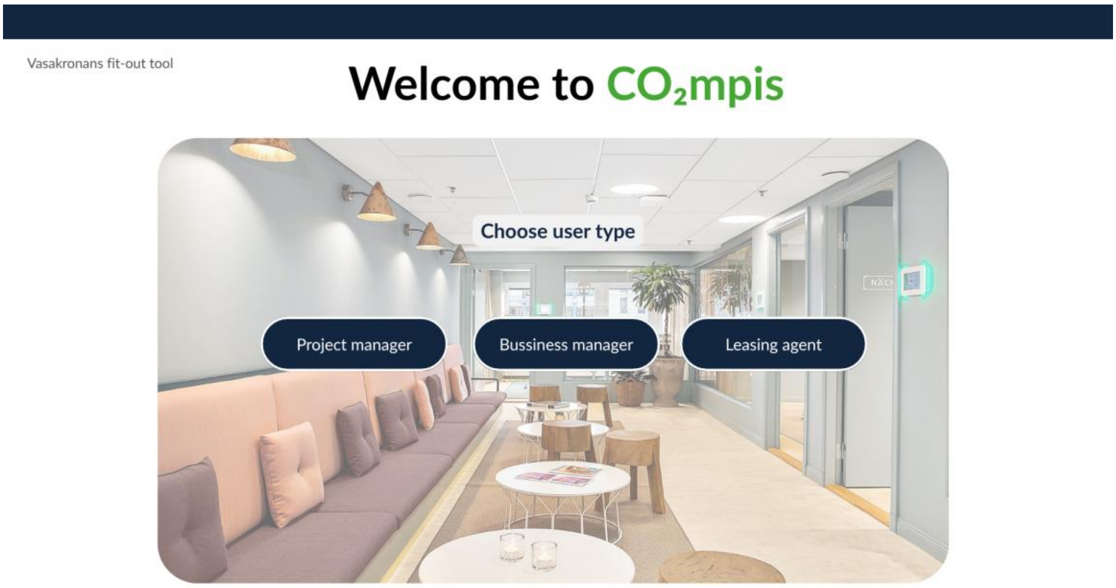
All actions in fit outs

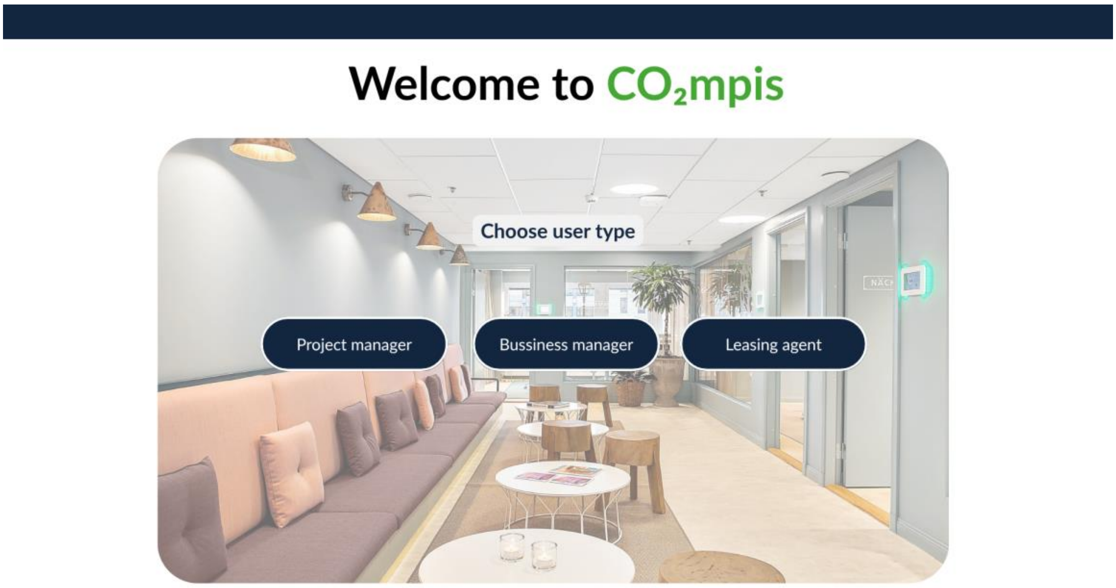
Förtydlgande kategorier	Bygg	Antal	Summa CO2/ Antal där åtgärd görs
Brandtätningar & Byggkompletering	Fönsterbänkar justering	1	650
Brandtätningar & Byggkompletering	Brandtätning, skiva	2	136
Brandtätningar & Byggkompletering	Brandtätning, skum	2	27
Brandtätningar & Byggkompletering	Byggkomplettering bef väggar	1	10
Golv	Textilgolv	5	7824
Golv	Klinkergolv	3	1693
Golv	Trägolv	2	1526
Golv	Golvavjämning, 1 cm	4	1453
Golv	Textilgolv > 50% återvunnet	2	884
Golv	Linoleumgolv	1	515
Kaffestation (Modul)	Diskmaskin	2	394
Kaffestation (Modul)	Kylskåp, liten	2	332
Kaffestation (Modul)	Underskåp, smalt	2	36
Kaffestation (Modul)	Underskåp	2	36
Kaffestation (Modul)	Stänkskydd	2	24
Kaffestation (Modul)	Blandare	2	23
Kaffestation (Modul)	Fog, stänkskydd, silikonbaserad	2	15
Kaffestation (Modul)	Bänkskiva	2	12
Kaffestation (Modul)	Bottenventil/Vattenlås	2	10
Kaffestation (Modul)	Fog, stänkskydd, akrylbaserad	2	7
Kaffestation (Modul)	Hylla	2	5
Kaffestation (Modul)	Diskho	2	3
Kaffestation (Modul)	Konsoll	2	2
Kaffestation (Modul)	Spackel, stänkskydd	2	1
LED, armatur, st.	LED, armatur, st.	1	15
Mellanväggar & Dörrar	Måla väggar	6	554
Mellanväggar & Dörrar	Dörrportal	3	3366
Mellanväggar & Dörrar	Kaklad vägg	2	2413
Mellanväggar & Dörrar	Glasdörr - aluminiumram	1	2136
Mellanväggar & Dörrar	Platsbyggd vägg - Stålregel 44 Rw (dB)	4	1744
Mellanväggar & Dörrar	Modulvägg - Glas, aluminiumram	7	1702
Mellanväggar & Dörrar	Platsbyggd vägg - Stålregel 35 Rw (dB)	2	1119
Mellanväggar & Dörrar	Modulvägg - MDF	1	213
Mellanväggar & Dörrar	Modulvägg - Gips	1	78
Mellanväggar & Dörrar	Innerdörr - trä	3	55
Mellanväggar & Dörrar	Innerdörr - trä & brandklassad	1	18
Nyckeltal Belysning	Nyckeltal Belysning	2	4462
Nyckeltal Brandlarm	Nyckeltal Brandlarm	1	252
Nyckeltal El (Modul)	Elkabel - nyckeltal El	5	3322
Nyckeltal El (Modul)	Kabelskyddsrör - nyckeltal El	5	808
Nyckeltal El (Modul)	Elcentral - nyckeltal El	5	743
Nyckeltal Styr	Nyckeltal Styr	4	1968
Nyckeltal Ventilation (Modul)	Ventilationskanal, 400 mm	6	3327
Nyckeltal Ventilation (Modul)	Ljuddämpare	6	923
Nyckeltal Ventilation (Modul)	Baffel, passiv	6	263
Nyckeltal Ventilation (Modul)	Ventilationskanal, 125 mm (D)	6	780
Nyckeltal Ventilation (Modul)	Spjäll	6	27

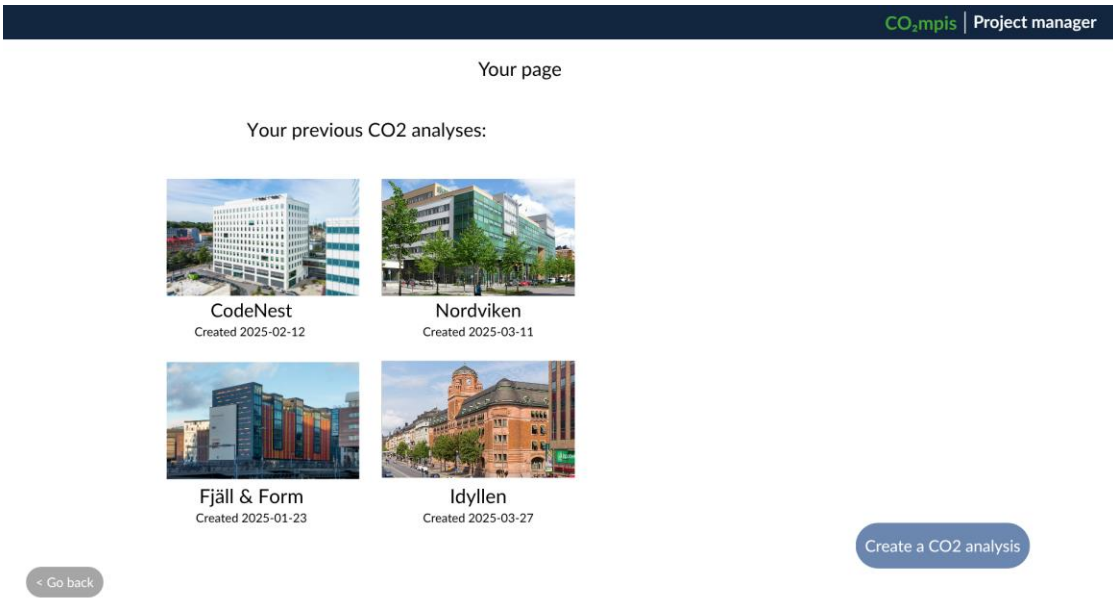
Nyckeltal VS (Modul)	Isolering, kyla - nyckeltal VS	4	651
Nyckeltal VS (Modul)	Isolering, värme och varmvatten, glasull - nyckeltal VS	4	850
Nyckeltal VS (Modul)	Rostfria rör - nyckeltal VS	4	2832
Nyckeltal VS (Modul)	Element kvm	4	2298
Nyckeltal VS (Modul)	PEX Värme - nyckeltal VS	4	1595
Nyckeltal VS (Modul)	Kopparrör - nyckeltal VS	4	1772
Pentry (sakvara)	Mikro	3	740
Pentry (sakvara)	Kylskåp	1	582
Pentry (sakvara)	Diskmaskin	1	393
Pentry (sakvara)	Bänkskiva	2	12
Pentry Stort (Modul)	Kylskåp	3	582
Pentry Stort (Modul)	Diskmaskin	3	788
Pentry Stort (Modul)	Mikro	3	404
Pentry Stort (Modul)	LED, panel	3	95
Pentry Stort (Modul)	Underskåp	3	180
Pentry Stort (Modul)	Diskho	3	35
Pentry Stort (Modul)	Stänkskydd	3	37
Pentry Stort (Modul)	Blandare	3	23
Pentry Stort (Modul)	Överskåp	3	110
Pentry Stort (Modul)	Överskåp, litet	3	22
Pentry Stort (Modul)	Fog, stänkskydd, silikonbaserad	3	13
Pentry Stort (Modul)	Bänkskiva	3	12
Pentry Stort (Modul)	Bottenventil/Vattenlås	3	10
Pentry Stort (Modul)	Fog, stänkskydd, akrylbaserad	3	6
Pentry Stort (Modul)	Spackel, stänkskydd	3	3
Pentry Stort (Modul)	Täcksidor, passbitar L	3	0
Pentry, litet (Modul)	Kylskåp	1	291
Pentry, litet (Modul)	Diskmaskin	1	394
Pentry, litet (Modul)	Mikro	1	202
Pentry, litet (Modul)	LED, panel	1	47
Pentry, litet (Modul)	Underskåp	1	90
Pentry, litet (Modul)	Diskho	1	18
Pentry, litet (Modul)	Stänkskydd	1	18
Pentry, litet (Modul)	Blandare	1	12
Pentry, litet (Modul)	Överskåp	1	55
Pentry, litet (Modul)	Överskåp, litet	1	11
Pentry, litet (Modul)	Fog, stänkskydd, silikonbaserad	1	7
Pentry, litet (Modul)	Bänkskiva	1	6
Pentry, litet (Modul)	Bottenventil/Vattenlås	1	5
Pentry, litet (Modul)	Fog, stänkskydd, akrylbaserad	1	3
Pentry, litet (Modul)	Spackel, stänkskydd	1	1
Pentry, litet (Modul)	Täcksidor, passbitar L	1	0
Renovering Pentry Enkel (Modul)	Täcksidor, passbitar M	2	0
Renovering Pentry Enkel (Modul)	Överskåp	2	55
Renovering Pentry Enkel (Modul)	Stänkskydd	2	37
Renovering Pentry Enkel (Modul)	Fog, stänkskydd, silikonbaserad	2	13
Renovering Pentry Enkel (Modul)	Spackel, stänkskydd	2	3
Renovering Pentry Enkel (Modul)	Blandare	2	12
Renovering Pentry Enkel (Modul)	Bänkskiva	2	6

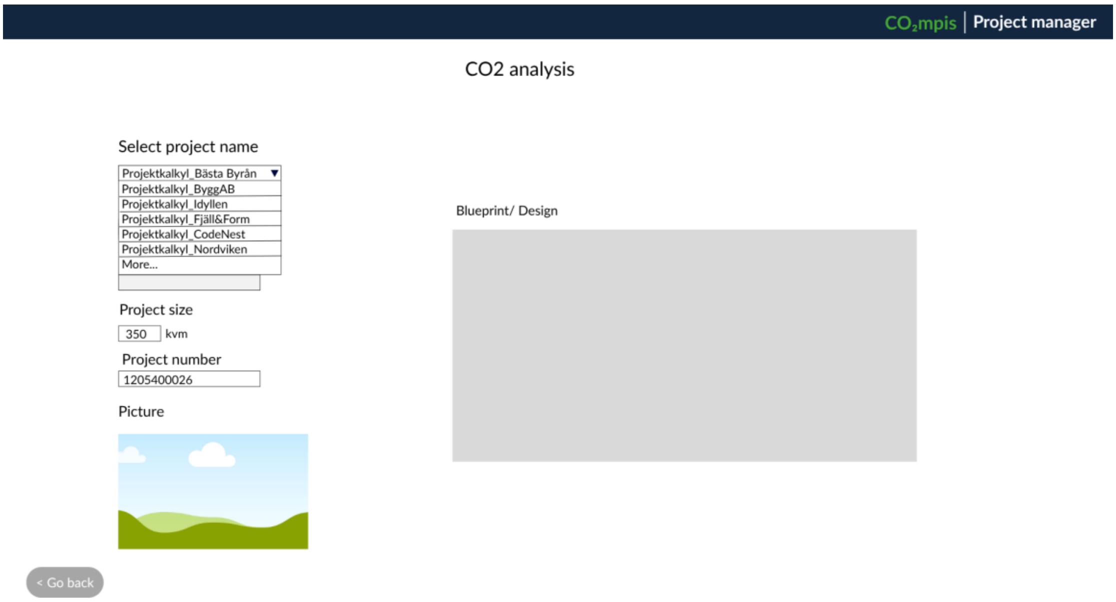
Renovering WC Enkel (Modul)	Klinker	1	200
Renovering WC Enkel (Modul)	Kakel	1	960
Renovering WC Enkel (Modul)	Fog, kakel och klinker, silikonbaserad	1	422
Renovering WC Enkel (Modul)	Blandare till handfat	1	36
Renovering WC Enkel (Modul)	Spegel	1	28
Renovering WC Enkel (Modul)	Spackel, kakel och klinker	1	76
Renovering WC Inkl porslin (Modul)	WC-sits	1	110
Renovering WC Inkl porslin (Modul)	Handfat	1	42
Renovering WC Inkl porslin (Modul)	Klinker	1	40
Renovering WC Inkl porslin (Modul)	Kakel	1	192
Renovering WC Inkl porslin (Modul)	Blandare till handfat	1	7
Renovering WC Inkl porslin (Modul)	Fog, kakel och klinker, silikonbaserad	1	80
Renovering WC Inkl porslin (Modul)	Spegel	1	6
Renovering WC Inkl porslin (Modul)	Fixtur för WC	1	7
Renovering WC Inkl porslin (Modul)	Vattenlås Handfat	1	2
Renovering WC Inkl porslin (Modul)	Spackel, kakel och klinker	1	15
RWC - Silikonbaserad fog (Modul)	WC-sits	4	193
RWC - Silikonbaserad fog (Modul)	Duschhörna, glas	4	117
RWC - Silikonbaserad fog (Modul)	Handfat	4	74
RWC - Silikonbaserad fog (Modul)	Duschblandare	4	24
RWC - Silikonbaserad fog (Modul)	Klinker	4	163
RWC - Silikonbaserad fog (Modul)	Kakel	4	693
RWC - Silikonbaserad fog (Modul)	Armstöd	4	28
RWC - Silikonbaserad fog (Modul)	Blandare till handfat	4	12
RWC - Silikonbaserad fog (Modul)	Fog, kakel och klinker, silikonbaserad	4	294
RWC - Silikonbaserad fog (Modul)	Spegel	4	10
RWC - Silikonbaserad fog (Modul)	Golvavjämning	4	49
RWC - Silikonbaserad fog (Modul)	Fog, kakel och klinker, akrylbaserad	4	143
RWC - Silikonbaserad fog (Modul)	Fixtur för WC	4	10
RWC - Silikonbaserad fog (Modul)	Vattenlås handfat	4	4
RWC - Silikonbaserad fog (Modul)	Tätskiktsmatta	4	140
RWC - Silikonbaserad fog (Modul)	Spackel, kakel och klinker	4	56
Sprinklersystem - nyckeltal sprinkler	Sprinklersystem - nyckeltal sprinkler	1	1492
Tak	Undertak	6	2889
Tak	Akustikplattor	1	962
Tak	Måla undertak	2	25
WC - Silikonbaserad fog (Modul)	WC-sits	3	403
WC - Silikonbaserad fog (Modul)	Handfat	3	154
WC - Silikonbaserad fog (Modul)	Klinker	3	146
WC - Silikonbaserad fog (Modul)	Kakel	3	704
WC - Silikonbaserad fog (Modul)	Fog, kakel och klinker, silikonbaserad	3	309
WC - Silikonbaserad fog (Modul)	Blandare till handfat	3	26
WC - Silikonbaserad fog (Modul)	Spegel	3	21
WC - Silikonbaserad fog (Modul)	Fixtur för WC	3	21
WC - Silikonbaserad fog (Modul)	Golvavjämning	3	44
WC - Silikonbaserad fog (Modul)	Fog, kakel och klinker, akrylbaserad	3	142
WC - Silikonbaserad fog (Modul)	Vattenlås Handfat	3	9
WC - Silikonbaserad fog (Modul)	Tätskiktsmatta	3	153
WC - Silikonbaserad fog (Modul)	Spackel, kakel och klinker	3	56

Appendix E
Wireframe

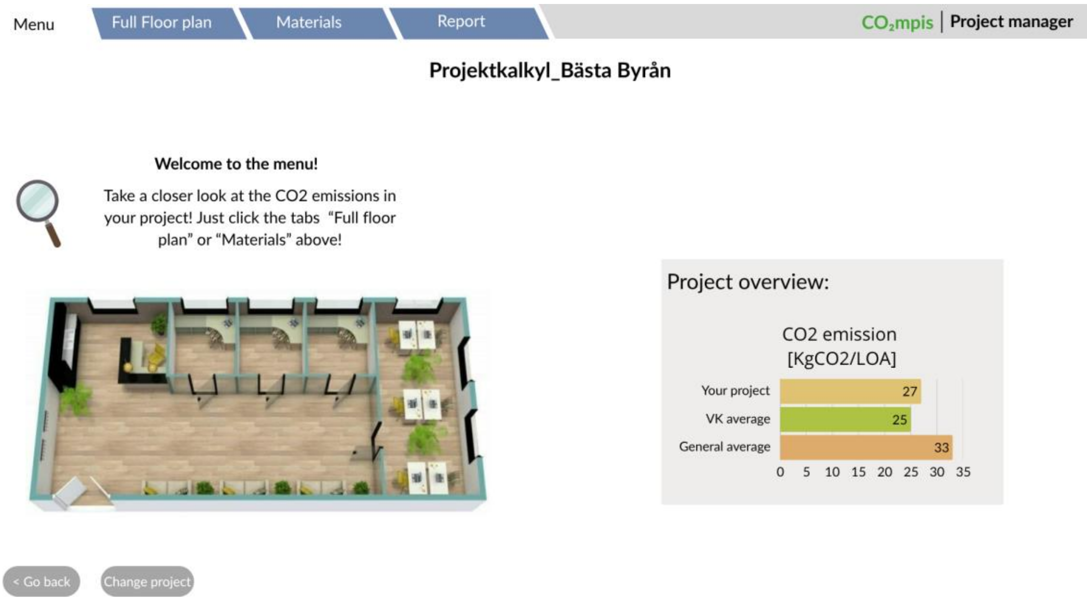


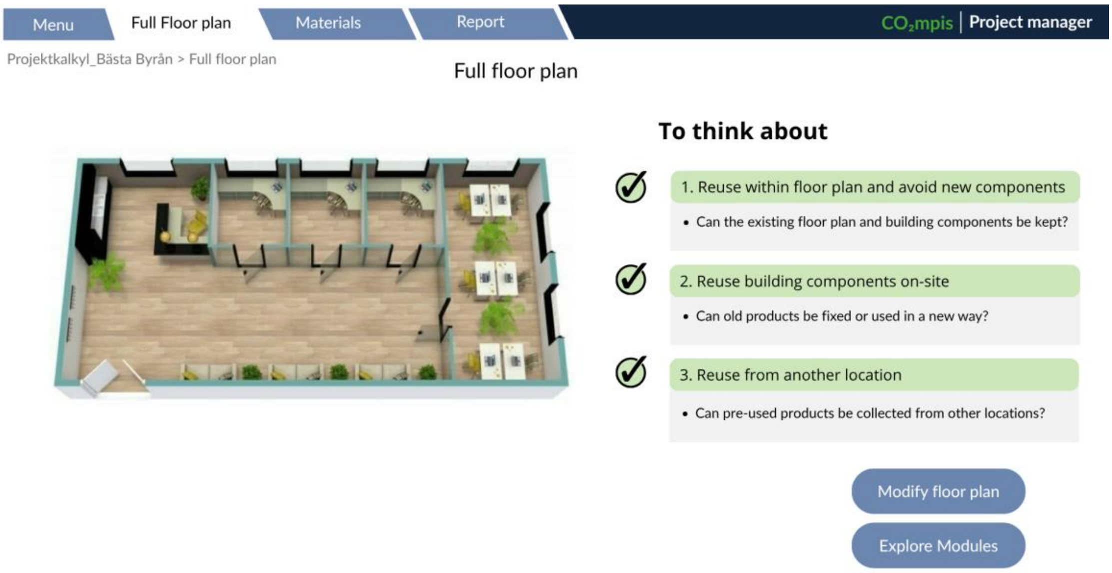


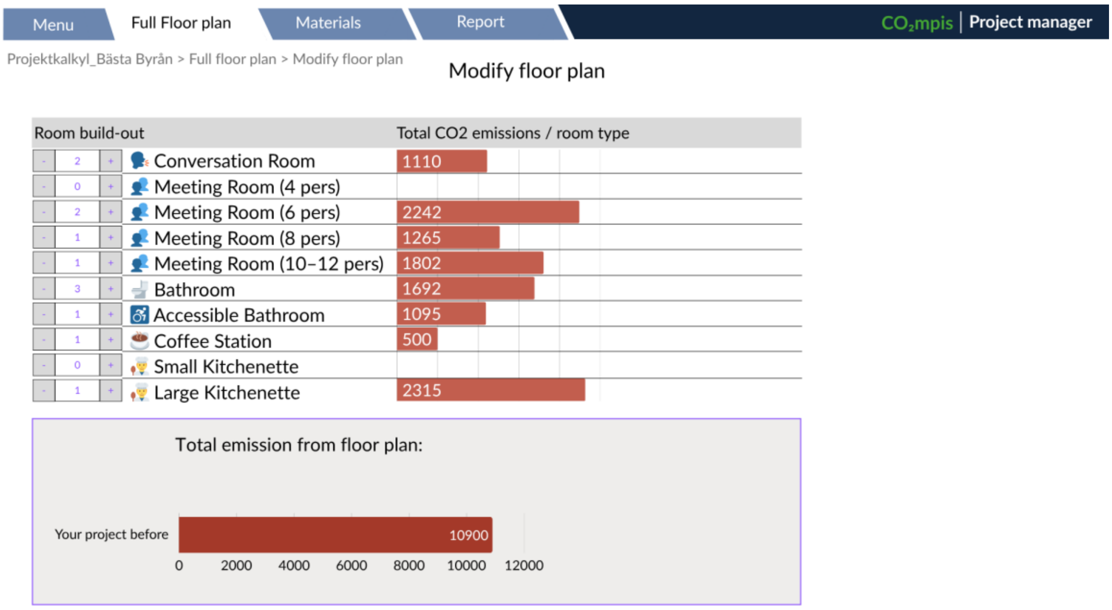

CO₂mpis | Project manager
Your page
Your previous CO2 analyses:
CodeNest
Created 2025-02-12
Nordviken
Created 2025-03-11
Fjäll & Form
Created 2025-01-23
Idyllen
Created 2025-03-27
Create a CO2 analysis
< Go back

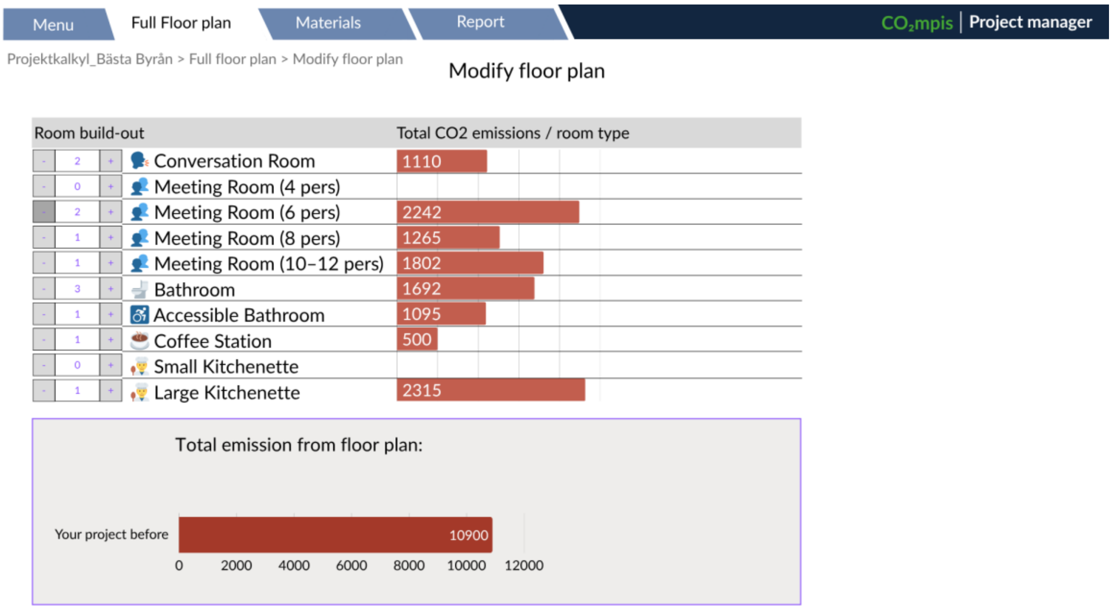

CO₂mpis | Project manager
CO2 analysis
Select project name
Projektkalkyl_Bästa Byrån
Projektkalkyl_ByggAB
Projektkalkyl_Idyllen
Projektkalkyl_Fjäll&Form
Projektkalkyl_CodeNest
Projektkalkyl_Nordviken
More...
Project size
350 kvm
Project number
1205400026
Picture
Blueprint/ Design
< Go back


CO₂mpis | Project manager
CO2 analysis
Select project name
Projektkalkyl_Bästa Byrån
Project type
Customized office
Building name
Platinan
Project size
350 kvm
Project number
1205400026
Picture
Blueprint/ Design
Next
< Go back


Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån
Welcome to the menu!
Take a closer look at the CO2 emissions in your project! Just click the tabs "Full floor plan" or "Materials" above!
Project overview:
CO2 emission [KgCO2/LOA]
Your project 27
VK average 25
General average 33
0 5 10 15 20 25 30 35
< Go back
Change project


Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Full floor plan
Full floor plan
To think about
1. Reuse within floor plan and avoid new components
Can the existing floor plan and building components be kept?
2. Reuse building components on-site
Can old products be fixed or used in a new way?
3. Reuse from another location
Can pre-used products be collected from other locations?
Modify floor plan
Explore Modules


Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Full floor plan > Modify floor plan
Modify floor plan
Room build-out
Total CO2 emissions / room type
2 Conversation Room 1110
0 Meeting Room (4 pers)
2 Meeting Room (6 pers) 2242
1 Meeting Room (8 pers) 1265
1 Meeting Room (10–12 pers) 1802
3 Bathroom 1692
1 Accessible Bathroom 1095
1 Coffee Station 500
0 Small Kitchenette
1 Large Kitchenette 2315
Total emission from floor plan:
Your project before
10900
0
2000
4000
6000
8000
10000
12000


Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Full floor plan > Modify floor plan
Modify floor plan
Room build-out
Total CO2 emissions / room type
2 Conversation Room 1110
0 Meeting Room (4 pers)
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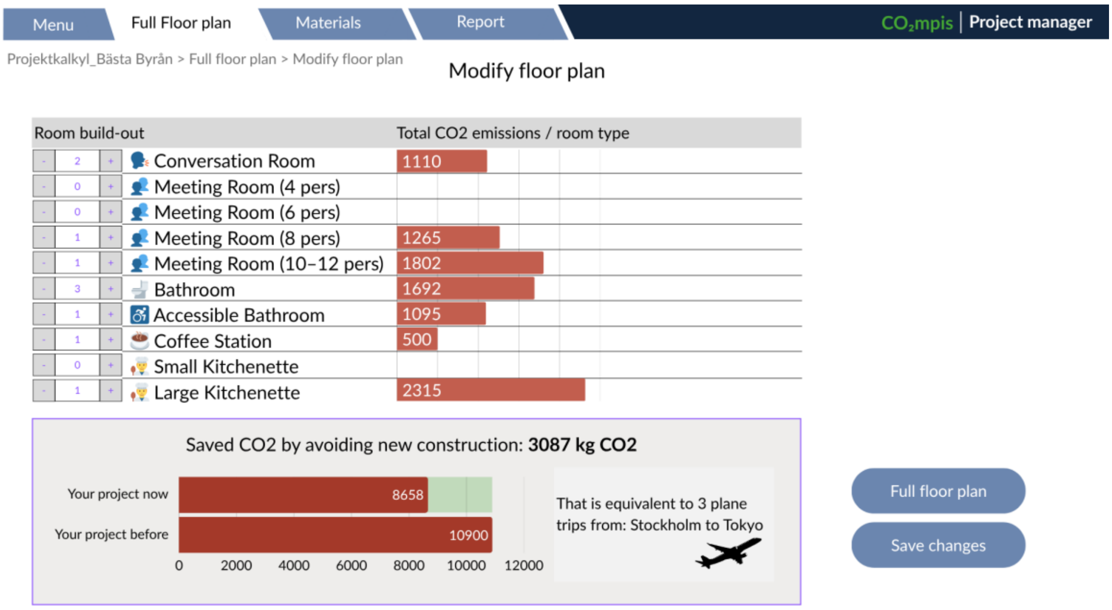
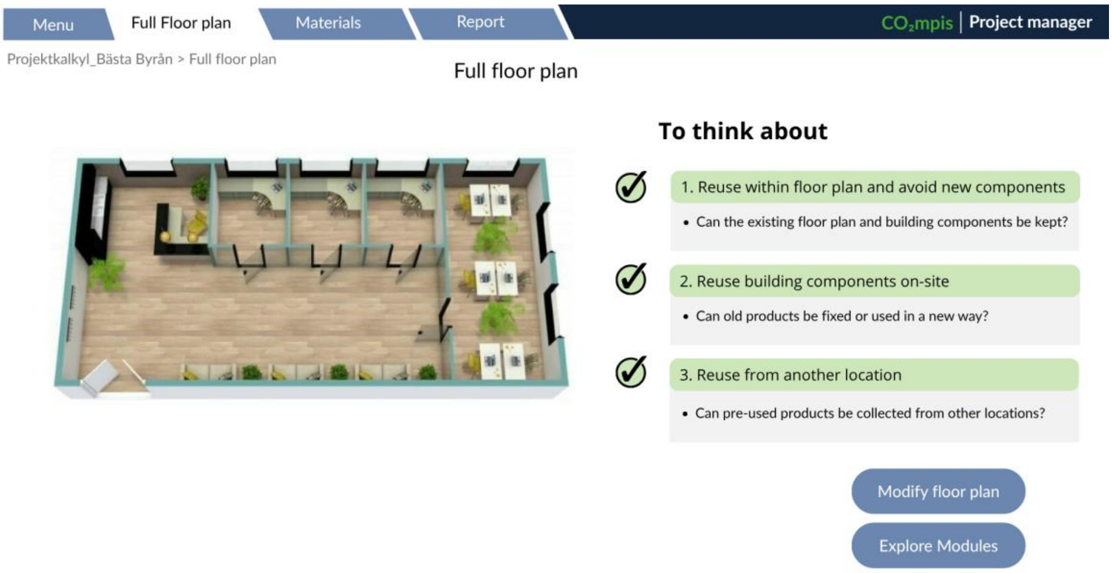
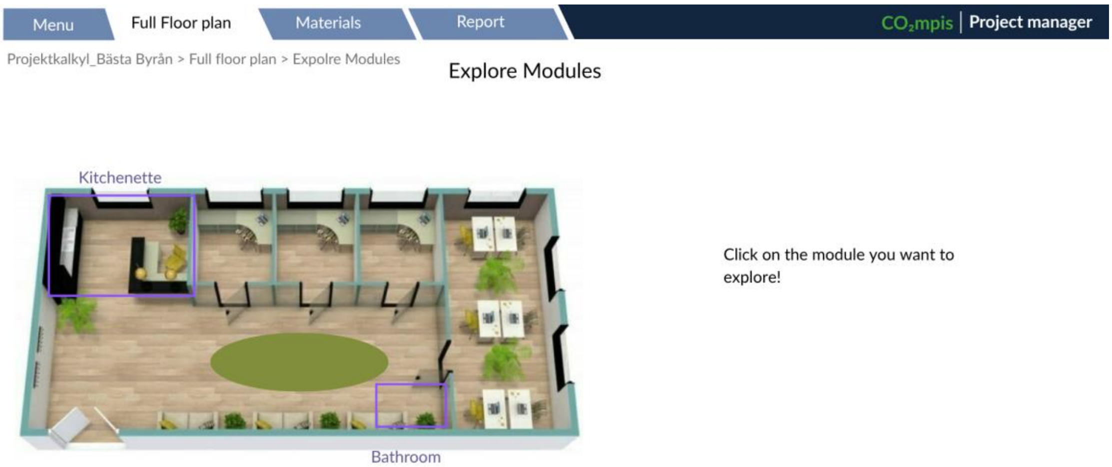
1 Meeting Room (8 pers) 1265
1 Meeting Room (10–12 pers) 1802
3 Bathroom 1692
1 Accessible Bathroom 1095
1 Coffee Station 500
0 Small Kitchenette
1 Large Kitchenette 2315
Total emission from floor plan:
Your project before 10900
0 2000 4000 6000 8000 10000 12000

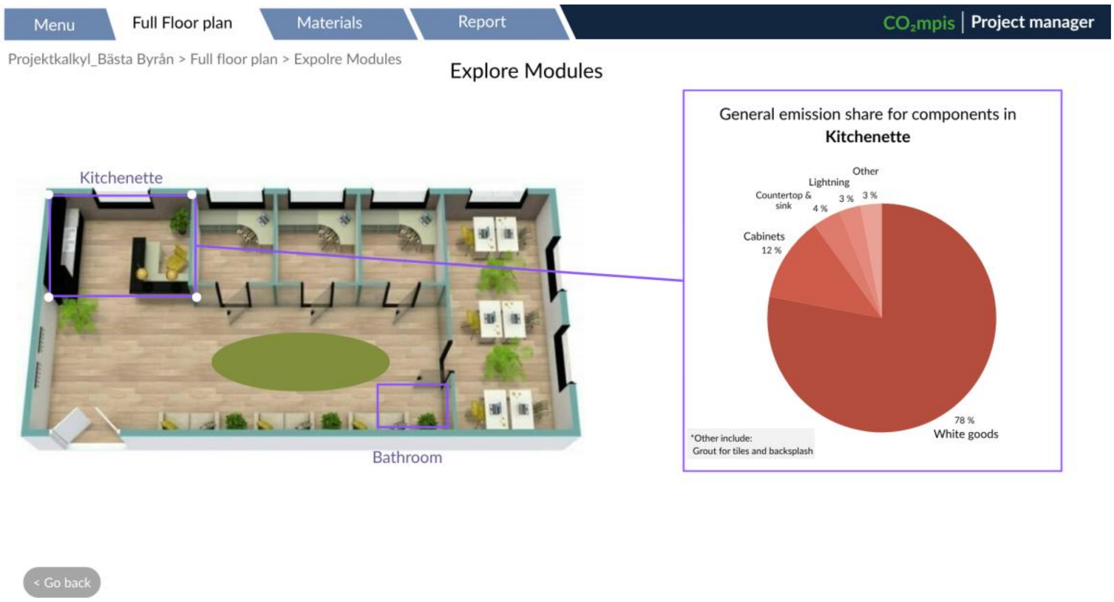

Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Full floor plan > Modify floor plan
Modify floor plan
Room build-out
Total CO2 emissions / room type
2 Conversation Room 1110
0 Meeting Room (4 pers)
0 Meeting Room (6 pers)
1 Meeting Room (8 pers) 1265
1 Meeting Room (10–12 pers) 1802
3 Bathroom 1692
1 Accessible Bathroom 1095
1 Coffee Station 500
0 Small Kitchenette
1 Large Kitchenette 2315
Saved CO2 by avoiding new construction: 3087 kg CO2
Your project now 8658
Your project before 10900
0 2000 4000 6000 8000 10000 12000
That is equivalent to 3 plane trips from: Stockholm to Tokyo
Full floor plan
Save changes



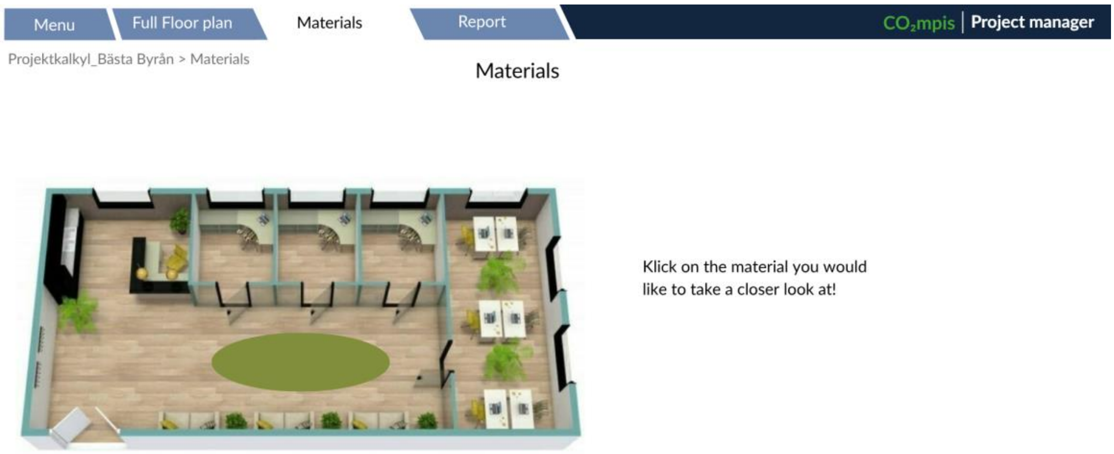
Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Full floor plan
Full floor plan
To think about
1. Reuse within floor plan and avoid new components
• Can the existing floor plan and building components be kept?
2. Reuse building components on-site
• Can old products be fixed or used in a new way?
3. Reuse from another location
• Can pre-used products be collected from other locations?
Modify floor plan
Explore Modules



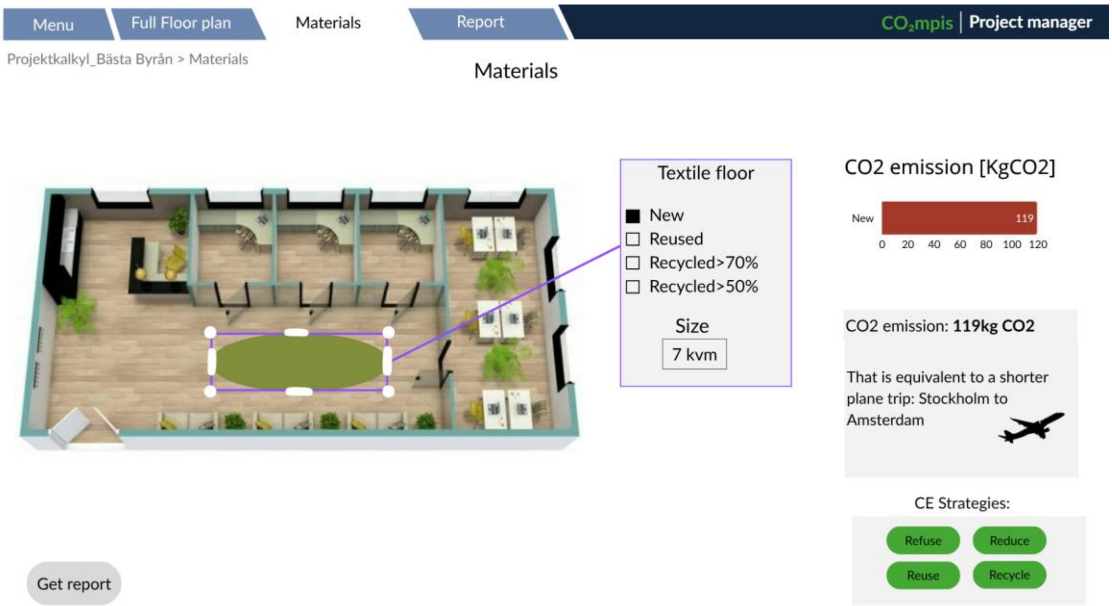
Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Full floor plan > Expolre Modules
Explore Modules
Kitchenette
Bathroom
Click on the module you want to explore!



Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Full floor plan > Expolre Modules
Explore Modules
Kitchenette
Bathroom
General emission share for components in Kitchenette
Other
Lightning
Countertop & sink
3 %
3 %
4 %
Cabinets 12 %
78 % White goods
*Other include: Grout for tiles and backsplash
< Go back



Menu
Full Floor plan
Materials
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Materials
Materials
Klick on the material you would like to take a closer look at!


Menu
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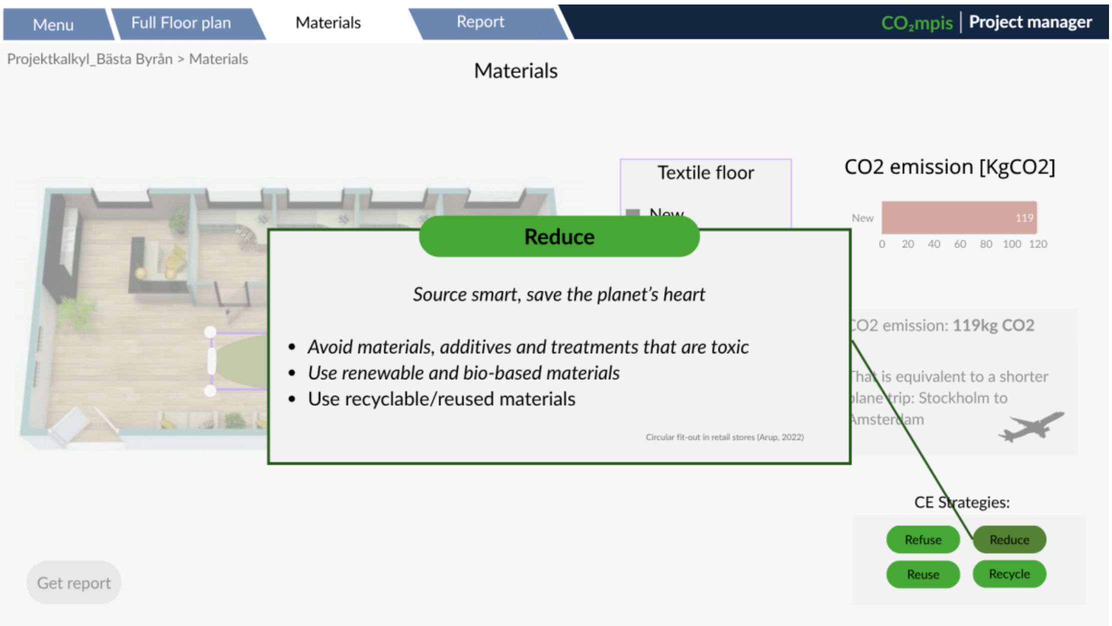
Projektkalkyl_Bästa Byrån > Materials
Materials
Textile floor
New
Reused
Recycled>70%
Recycled>50%
Size
7 kvm
CO2 emission [KgCO2]
New
119
0 20 40 60 80 100 120
CO2 emission: 119kg CO2
That is equivalent to a shorter plane trip: Stockholm to Amsterdam
CE Strategies:
Refuse
Reduce
Reuse
Recycle
Get report


Menu
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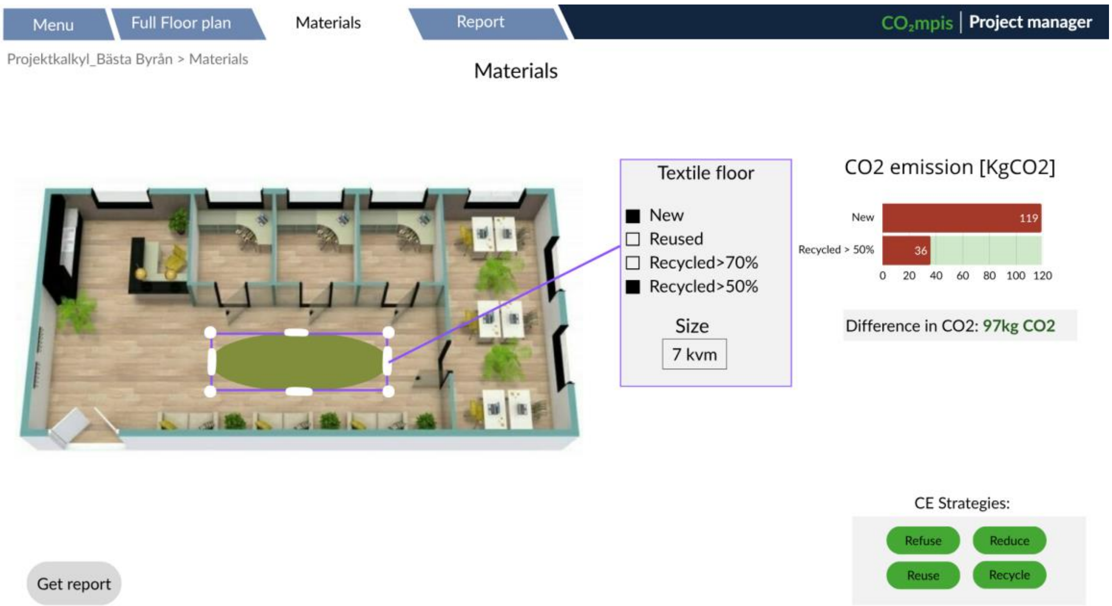
Projektkalkyl_Bästa Byrån > Materials
Materials
Textile floor
CO2 emission [KgCO2]
Reduce
Source smart, save the planet's heart
Avoid materials, additives and treatments that are toxic
Use renewable and bio-based materials
Use recyclable/reused materials
Circular fit-out in retail stores (Arup, 2022)
CE Strategies:
Refuse
Reduce
Reuse
Recycle
Get report


Menu
Full Floor plan
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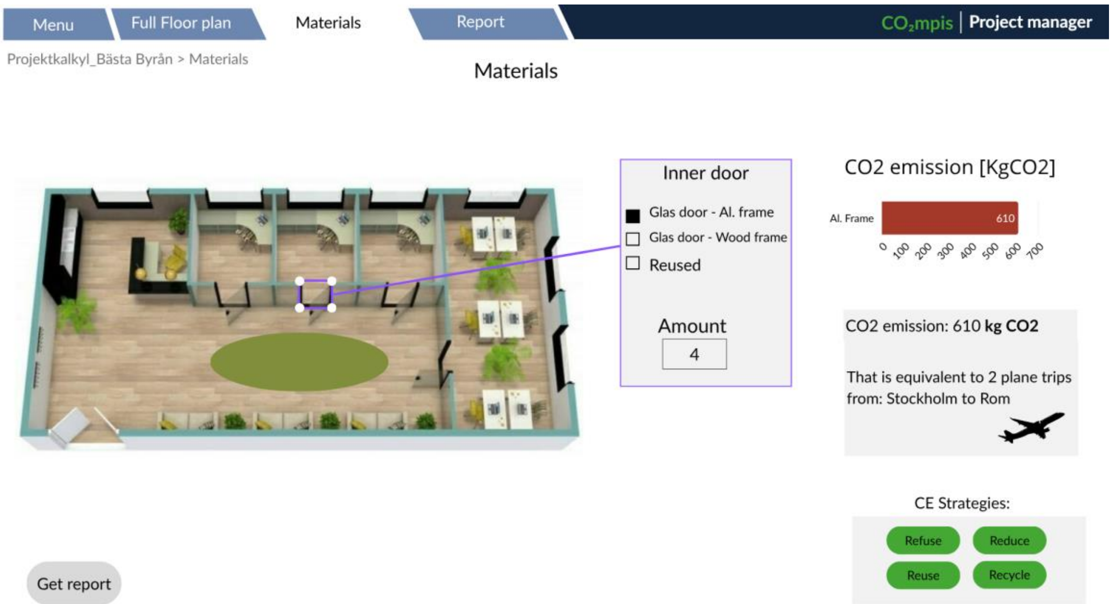
Projektkalkyl_Bästa Byrån > Materials
Materials
Textile floor
New
Reused
Recycled>70%
Recycled>50%
Size
7 kvm
CO2 emission [KgCO2]
New
119
Recycled > 50%
36
0 20 40 60 80 100 120
Difference in CO2: 97kg CO2
CE Strategies:
Refuse
Reduce
Reuse
Recycle
Get report


Menu
Full Floor plan
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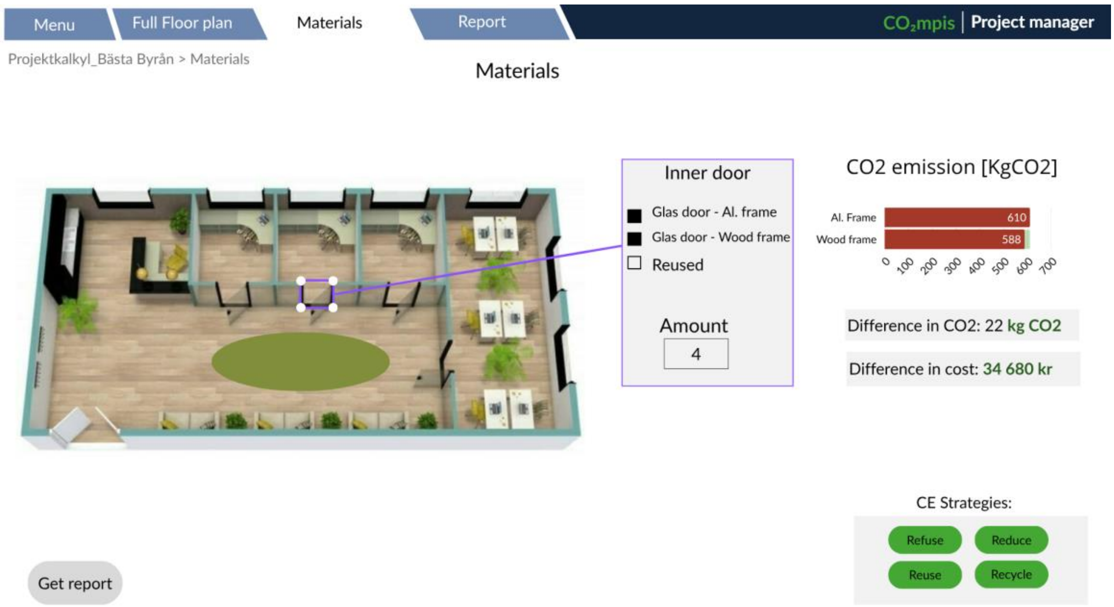
Projektkalkyl_Bästa Byrån > Materials
Materials
Inner door
Glas door - Al. frame
Glas door - Wood frame
Reused
Amount
4
CO2 emission [KgCO2]
Al. Frame
610
0 100 200 300 400 500 600 700
CO2 emission: 610 kg CO2
That is equivalent to 2 plane trips
from: Stockholm to Rom
CE Strategies:
Refuse
Reduce
Reuse
Recycle
Get report


Menu
Full Floor plan
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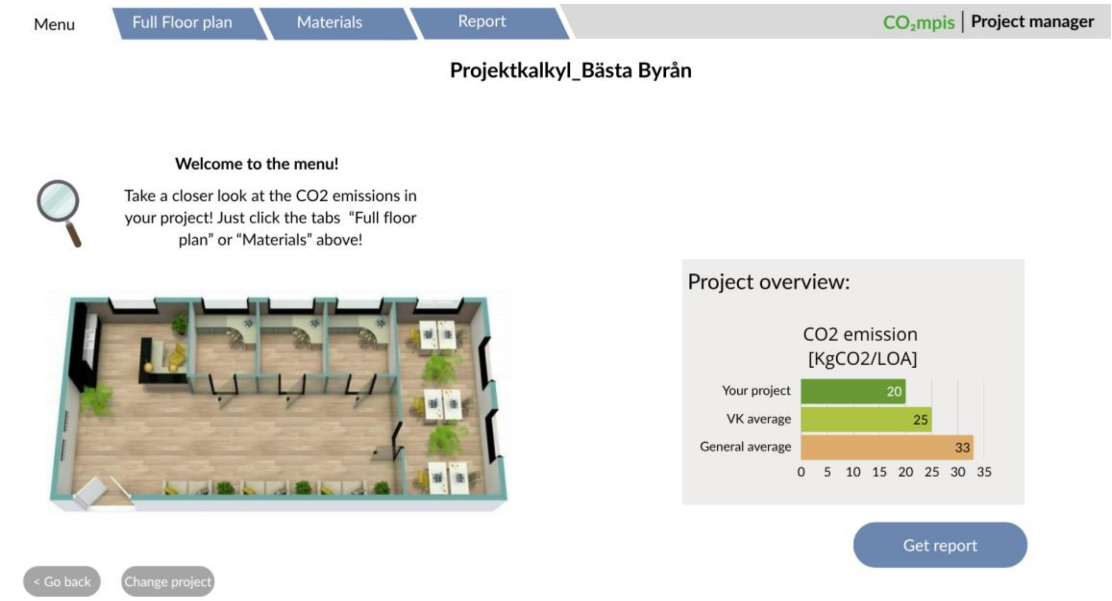
Projektkalkyl_Bästa Byrån > Materials
Materials
Inner door
Glas door - Al. frame
Glas door - Wood frame
Reused
Amount
4
CO2 emission [KgCO2]
Al. Frame
610
Wood frame
588
0 100 200 300 400 500 600 700
Difference in CO2: 22 kg CO2
Difference in cost: 34 680 kr
CE Strategies:
Refuse
Reduce
Reuse
Recycle
Get report


Menu
Full Floor plan
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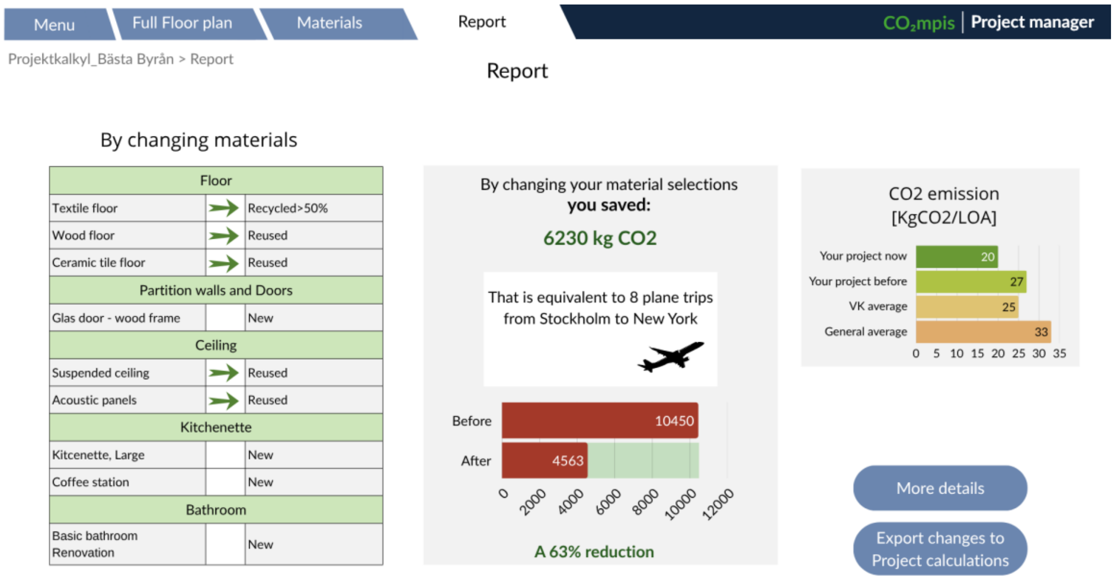
Projektkalkyl_Bästa Byrån
Welcome to the menu!
Take a closer look at the CO2 emissions in your project! Just click the tabs "Full floor plan" or "Materials" above!
Project overview:
CO2 emission [KgCO2/LOA]
Your project
20
VK average
25
General average
33
0 5 10 15 20 25 30 35
Get report
< Go back
Change project


Menu
Full Floor plan
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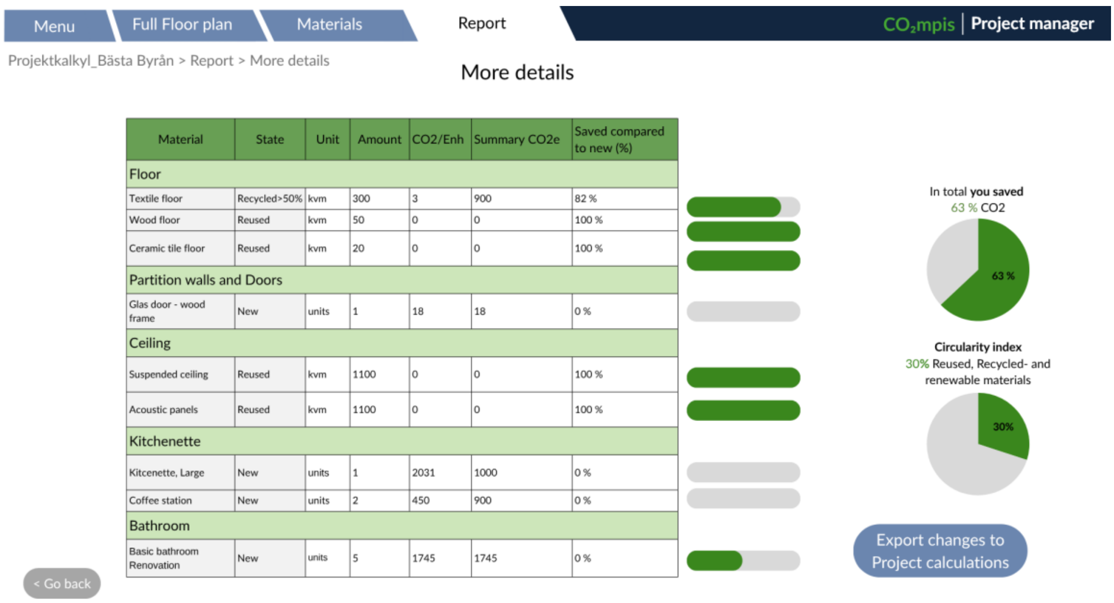
Projektkalkyl_Bästa Byrån > Report
Report
By changing materials
Floor
Textile floor → Recycled>50%
Wood floor → Reused
Ceramic tile floor → Reused
Partition walls and Doors
Glas door - wood frame New
Ceiling
Suspended ceiling → Reused
Acoustic panels → Reused
Kitchenette
Kitcenette, Large New
Coffee station New
Bathroom
Basic bathroom Renovation New
By changing your material selections
you saved:
6230 kg CO2
That is equivalent to 8 plane trips from Stockholm to New York
Before 10450
After 4563
0 2000 4000 6000 8000 10000 12000
A 63% reduction
CO2 emission
[KgCO2/LOA]
Your project now 20
Your project before 27
VK average 25
General average 33
0 5 10 15 20 25 30 35
More details
Export changes to Project calculations


Menu
Full Floor plan
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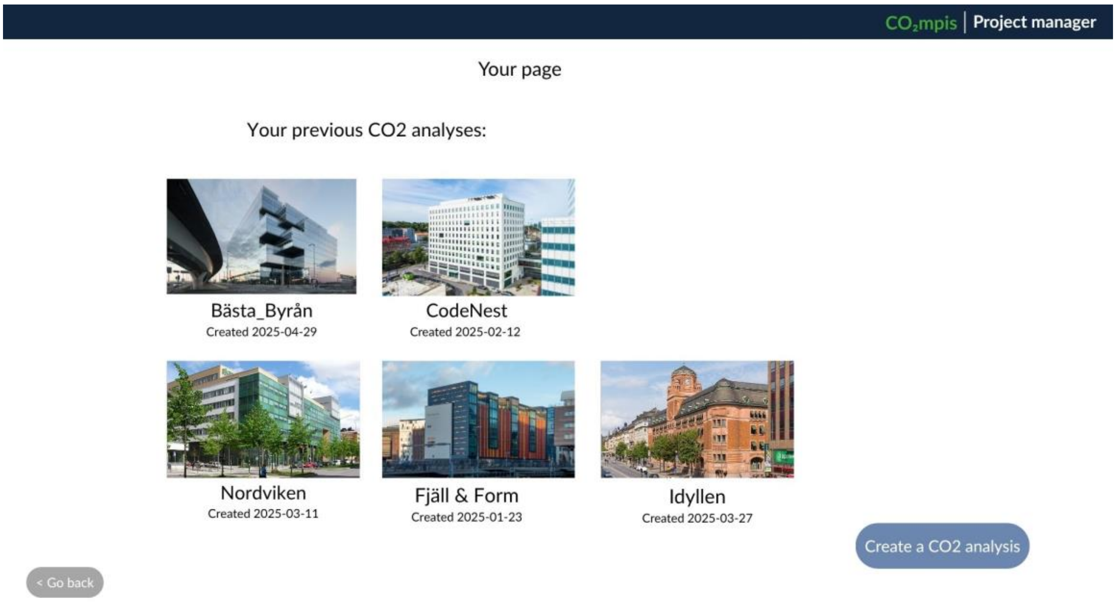
Report
CO₂mpis | Project manager
Projektkalkyl_Bästa Byrån > Report > More details
More details
Material | State | Unit | Amount | CO2/Enh | Summary CO2e | Saved compared to new (%)
Floor
Textile floor | Recycled>50% | kvm | 300 | 3 | 900 | 82 %
Wood floor | Reused | kvm | 50 | 0 | 0 | 100 %
Ceramic tile floor | Reused | kvm | 20 | 0 | 0 | 100 %
Partition walls and Doors
Glas door - wood frame | New | units | 1 | 18 | 18 | 0 %
Ceiling
Suspended ceiling | Reused | kvm | 1100 | 0 | 0 | 100 %
Acoustic panels | Reused | kvm | 1100 | 0 | 0 | 100 %
Kitchenette
Kitcenette, Large | New | units | 1 | 2031 | 1000 | 0 %
Coffee station | New | units | 2 | 450 | 900 | 0 %
Bathroom
Basic bathroom Renovation | New | units | 5 | 1745 | 1745 | 0 %
In total you saved
63 % CO2
63 %
Circularity index
30% Reused, Recycled- and renewable materials
30%
Export changes to Project calculations
< Go back


CO2mpis
Project manager
Your page
Your previous CO2 analyses:
Bästa_Byrån
Created 2025-04-29
CodeNest
Created 2025-02-12
Nordviken
Created 2025-03-11
Fjäll & Form
Created 2025-01-23
Idyllen
Created 2025-03-27
Create a CO2 analysis
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