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Packaging waste-free delivery and operations at Oslo Airport terminal

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Glossary

Term	Description
Commercial unit	An entity in the terminal hall that is used for business purposes
F&B	Food and beverage
PANT	Deposit on bottles in Norway
Rp19	Returpunkt 19, one of the three waste stations at Oslo Airport
EU	European Union
Tenant	Business entity that rents space from Oslo Airport. See commercial unit

Acknowledgements

Dear reader,

I am writing this from home and realizing this moment is special. After 6 years of studying at the faculty of industrial design engineering at the TU Delft my time here has ended. This means I have reached the end of another chapter of my life. I am done being a student, for now, but as my grandmother proved, it comforts me to know I can always return to learn more. The past years have been some good years, in which I made more new friendships, developed myself, and discovered many new places. Therefore Delft will always hold a special place in my heart.

I want to give a special thanks to everyone who supported me during this project.

First off my TU Delft supervisors; Sonja van Dam and Jelle Zijlstra. But also my PhD mentor Elisabeth Tschavgova and Rita and Annette from Avinor. They have all been incredibly kind, inspirational, and open. But also gave good comments and critiques to develop myself and this project.

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And lastly, I would like to thank my family and friends for their support during this period. But also for taking in all the moments of my time as a student with me.

Even though the past year has been a difficult one, with different challenges, both mentally and physically, with a concussion and more it has been a great one and I got there at the end. And I am happy to share that I am proud. Not only of myself but also of everyone around me.

Sophie

Executive Summary

This master thesis resulted in a roadmap and a spacial intervention focusing on packaging waste reduction of commercial activities at Oslo airport. This project is carried out in collaboration with the EU-funded TULIPS project and Avinor, the operator of Oslo Airport.

The project was structured according to the double diamond model and has four different phases; discover, define, develop, and deliver (Design Council, n.d.).

The first phase is the discover phase, which started with research on the packaging industry, the context of the project at Oslo Airport, and the eco-impact of packaging. This phase underlined the different beneficial functions of packaging. However, it also showed the massive impact packaging has on damaging our environment and the complexity of the packaging industry. This complexity comes from the different values of stakeholders, but also from a lack of communication, making it hard to implement change in the industry. From an airport operator position, such as Avinor, it is impossible to reach zero packaging waste without collaboration, as essential changes need to be made from the product source up. To tackle and minimize packaging waste it is required to collaborate with stakeholders throughout the whole supply chain, which is why this project highlights collaboration. Nevertheless, there are many circular solutions already available on the market. However, these solutions are not yet fully optimized to reduce CO2 emissions over the entire product life cycle.

This creates a conflict: while reducing packaging waste at Oslo Airport is the main goal of Avinor and this project, it may not always contribute to achieving a net zero footprint, which is the main objective of TULIPS.

While visiting Oslo Airport different problem areas regarding packaging waste at Oslo Airport were identified. These areas are; single-use pallets, milk packaging, secondary packaging, cardboard, plastic foil, waste station layout/signage, and communication.

In the define phase, the goal for the deliverable was set. Since it was discovered that the packaging industry is complex and implementing existing interventions to minimize waste is not always beneficial, a roadmap to a packaging waste-free future was established as one of the design outcomes alongside a concept for one of the problem areas. This roadmap utilizes the research insights to set goals and propose design interventions for packaging waste reduction in operational processes. As for the concept, the direction of redesigning the layout and signage in the waste station was taken. The design goal set was to; “enable workers who are returning packaging solutions to easily detect the designated areas for these items, enhance trust in the circular packaging economy, and increase capacity for future circular solutions”

In the develop phase the concept and the roadmap were drafted and iterations were made after testing. In the deliver phase the outcomes were presented. The concept makes use of different methods of wayfinding, optimizes the space with signage, and proposes a new layout. A visualization of the redesigned waste station is presented at the end of the report.

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Introduction

In this introduction the scope, essential background information and the project goal will be stated. This introduction chapter will end with the project and report structure.

This graduation project is part of the master Strategic Product design at the TU Delft and the focus is on creating a strategy to decrease packaging waste at Oslo airport. It also establishes a concept that can be tested and implemented in the short term. It was carried out in collaboration with Avinor, the operator of Oslo Airport.

The project goal

The main goal of this project is to limit the packaging needed in commercial operations and aid the move toward a circular economy for supply packaging. This is done to make supply operations more sustainable and to establish a closed-loop system for the resources used at Oslo Airport. Figure 1 explains the concept of a circular economy, where no waste is produced. An opportunity to create added value would be to enhance the supply chain efficiency through the potential packaging solution.

The problem

Airports need to find ways to eliminate waste as significant volumes of waste are generated during the operation of airports and the energy consumption and waste removal of busy airports resemble that of major cities (Sreenath et al., 2021). However, it is a challenge, which packaging could be reduced without compromising the integrity and quality of goods. Different stakeholders give different meanings to quality, integrity, and sustainability and face different challenges.

Since an airport has many different tenants and suppliers there are many different needs to take into account while designing a solution to the problem of reducing packaging waste. The different priorities could cause stakeholders to not work together at the same pace or in the same way to find a solution, making one solution not applicable to all.

For this project, the challenge is to find a way for commercial units in airports to make their packaging during supply operations less wasteful and find possible ways to work together and combine needs.

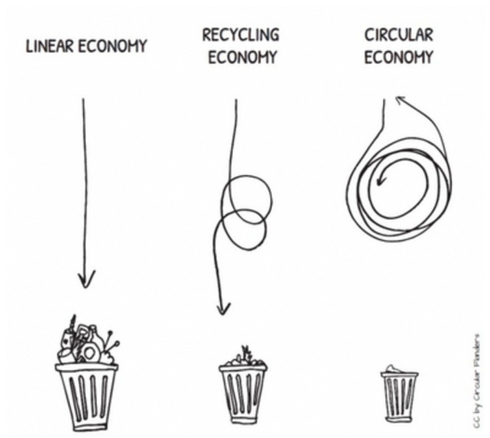


Figure 1: Linear vs Recycling vs Circular retrieved from https://www.agion.be/circulair-bouwen

The scope

The domain of packaging is very broad, therefore the topic required scoping. The packaging that this project focused on was narrowed down to supply packaging waste in the operations and transport of commercial units inside the terminal, leaving out other supply packaging waste that might have to be tackled in the future as well. During the project, certain focus areas at Oslo airport were identified to be able to make a significant difference. Moreover, the project focused only on the commercial Units located inside the terminal at Oslo Airport. This project included transport packaging like pallets, plastic crates, and cardboard boxes, which are most often secondary, tertiary, or even quaternary packaging. However, since this project focused on company operations, daily commercial operations were included, such as filling a coffee machine. This makes the primary packaging of milk, milk boxes, part of the problem as well. Due to the focus on waste based on daily operations and logistical processes, the packaging used by customers was not taken into account. This project therefore did not include primary packaging such as branded boxes in which customers buy perfume, sodas, or chocolate wrappers. Packaging for takeaway items was also outside of scope and tackled in another graduation project by Falcon et al. (2024), that is part of this series.

The timeframe for the project was from now up until 2050. The timeframe connects to the TULIPS timeframe, which also features these horizons with future visions for 2030 and 2050.

Background

Circularity models

To understand how a circular economy works and how we can alter our designs to become more circular there are various circularity models availible. Here two models that are widely known will be described. This gives a better understanding of the goal of this project and how we can strive to achieve it.

The first widely used model for circular strategies is called the 9R Framework, by Potting et al. (2017). The framework represents the degree of circularity of a strategy and it can be seen in Figure 2. The R-ladder has nine levels. The goal is to go towards a more circular strategy. The higher up the ladder, the better the strategy, with the best being R0 (refuse), R1 (rethink), and R2 (reduce), these are also the main focus in this project. The higher up the R-ladder the lower the use of raw materials. This model can be used to set goals and measure circularity.

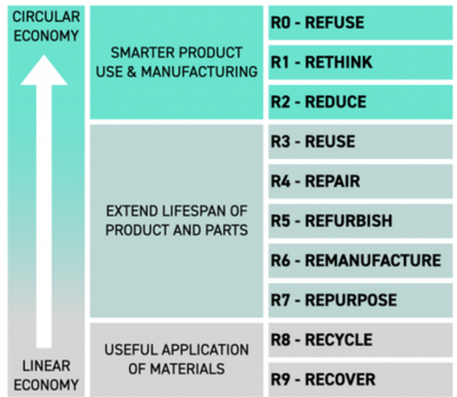


Figure 2: the 9R framework, retrieved from https://www.vaan.yachts/circular-design-isnt-rocket-science/

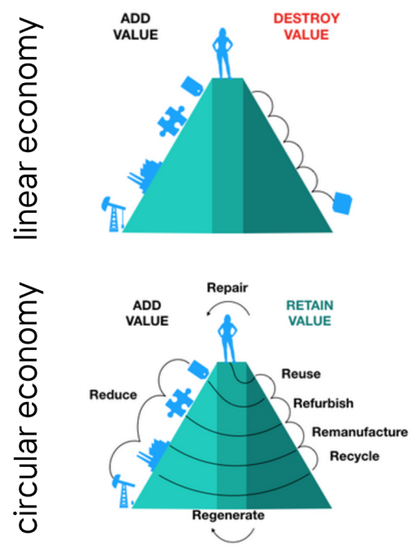


Figure 3: The value hill with R-model strategies (Pesti, 2020) , retrieved from https://theworldwidesupplychainfederation.com/media/2020/2/14/tnyscm19-leading-edge-circular-startups-that-ive-met-and-interacted-with

The second model is the value hill, it is used to visualize value creation and destruction. As a product moves from manufacturing to retail the product increases in value per step and when it arrives at the consumer it is at its highest value. Afterward, the value decreases, as can be seen in Figure 3. If we apply the value hill in a circular economy, we strive to increase value again, with different strategies that are mentioned in the R-model.

TULIPS and this project

Airports need to find ways to eliminate their waste as significant volumes of waste are generated during the operation of airports and the energy consumption and waste removal of busy airports resemble that of major cities (Sreenath et al., 2021). The EU is aiming to address this issue through an EU-funded project called TULIPS, which falls into Horizon Europe.

TULIPS contributes to the transition to low-carbon mobility and wants to enhance current sustainability actions at airports by 2026 by developing and implementing innovative solutions. In this project airports, airlines, knowledge institutes, and industrial partners collaborate to work on sustainable aviation (TULIPS, 2024). TULIPS is short for DemonsTrating lower pollUting soLutions for sustaInable airPorts acrosS Europe. TULIPS has organized its activities in 12 work packages.

This graduation assignment is part of TULIPS project work package 6, named Circular Airports, dedicated to the elimination of operational consumer/passenger waste (TULIPS, 2024b). The aim is to investigate the feasibility of both reducing packaging and finding reusable packaging alternatives for commercial operations in collaboration with commercial units and their suppliers to set up a circular baseline system for the airport. This graduation project aims to make work package six feasible and it will take place at Oslo airport in collaboration with Avinor and the TU Delft.

For TULIPS an interesting opportunity is the scalability of the solution developed within this graduation project. Learnings, interventions, and obstacles may be applicable to other airport contexts within the European context. Furthermore, the extent to which packaging decisions can be influenced by airport operators was proven to be a challenge during the project, and providing information on this is valuable to the project.

Avinor

Avinor is the biggest operator of airports in Norway, as they operate 43 airports, and Avinor is the case study in this project.

Avinor's role in society is to own, operate, and develop a national network of airports for the civilian sector and joint air navigation services for the civilian and military sectors in Norway (Avinor, n.d.). Regarding the circular economy, Avinor aims to work for optimal use of resources so that they reduce the need to take out new natural resources (Avinor, n.d.-a).

Oslo Airport has set zero waste ambitions for 2030, they want to go zero waste in certain areas, increase circularity, and move up on the R-ladder. Their goal is to reduce the total amount of waste related to daily operations by 50% by 2030, compared to 2022. Their ambition is to ensure efficient, seamless waste management at the airport and create a culture of waste prevention and reuse (Avinor, 2023). Some goals are;

- zero usable items are discarded
- zero food waste
- zero disposable items used
- zero incorrect sorting
- zero vision for residual waste

After 2030 they want to produce no waste and have only resources in circulation (Avinor, 2023).

The project goal

The aim set at the beginning of this project in collaboration with Avinor is to:

"Create a roadmap to implement more sustainable product packaging and alternatives and design and test a product packaging concept for 2030 to go towards a more circular economy for Oslo airport and terminal operators at Oslo airport."

Research questions

In order to structure the research some main and sub-research questions were established. These can be seen in Table 1.

Research Questions	
1.	For which deliveries could packaging be reduced without compromising the integrity and quality of goods?
2.	Where would the introduction of reusable packaging result in the greatest waste reduction?
Sub Questions	
3.	Is it feasible to build a centralized refill station for certain goods? What goods are best suited?
4.	What are the most commonly procured goods that come with the most packaging?
5.	Do other similar places (airports, shopping centers, etc.) have a similar system?
6.	What are the requirements of the commercial units in their daily operations?
7.	What reusable/re-fillable solutions are already in place at Oslo airport?
8.	Where would return products go if the delivery comes from abroad? The existing return orders seem to be all local, Norwegian products. Does it make sense to focus on international deliveries? Or rather increase focus on Norwegian suppliers?

Table 1: research questions

Visits to Oslo

Due to the context of the project, it was planned to visit Oslo Airport three times during the course of the project for research and testing purposes. These visits will be referred to in the project as visit 1, visit 2, and visit 3. Table 2 shows the goal of the visits and the time at which they took place.

#	Date	Goal
1.	26/2/2024 - 1/3/2024	Initail exporation, visit all tenants and mapping the problem
2.	9/4/2024 - 14/4/2024	Co-creation and further research
3.	5/6/2024 - 11/6/2024	Concept validation/testing and iteration

Table 2: site visit dates and goals

Stakeholders

In this project, many different stakeholders played a role and they are often referred to throughout this report. Figure 4 gives an overview of these different stakeholders. All partners of Oslo airport are confidential, therefore they are referred to with aliases, such as shop 1. The link between the alias and the real name can be found at the beginning of the confidential Appendix.

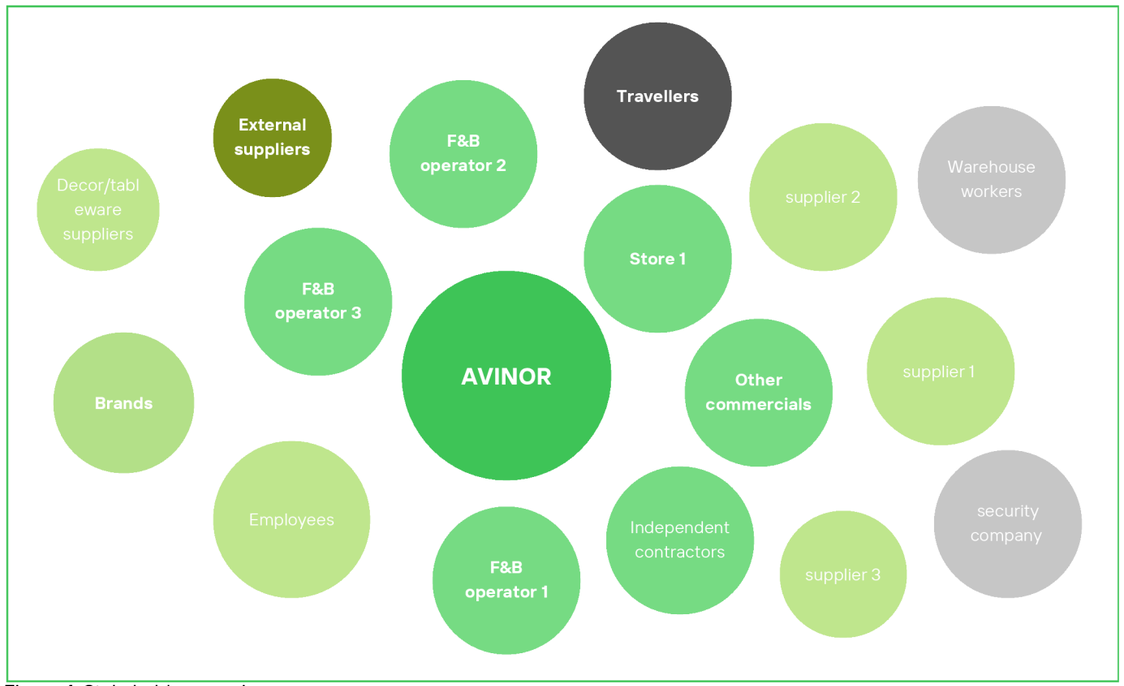


Figure 4: Stakeholder overview

Report structure

The project is structured according to the Double Diamond approach see Figure 5. The report mirrors this structure, by chronologically reporting on these different phases (Design Council, n.d.) .

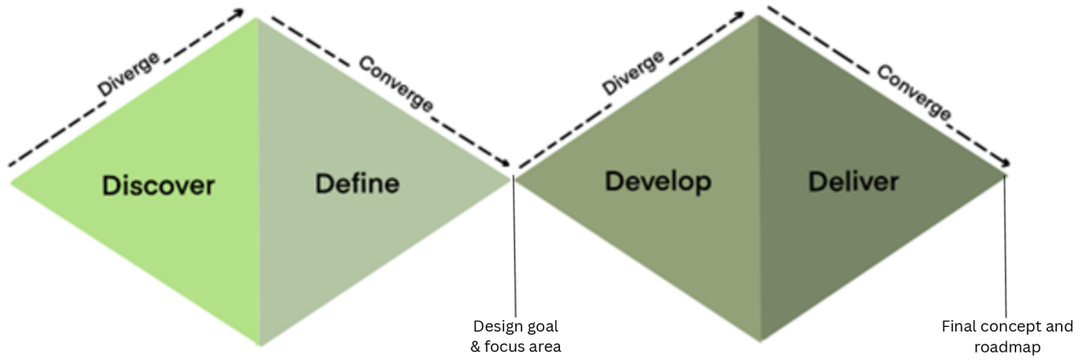


Figure 5: Double Diamond Approach

Discover (Chapters 3,4,5,6)

The discovery phase was divided into three main topics; the packaging industry, packaging at Oslo airport, and the Eco-impact of packaging. The topic "packaging industry" covered the background knowledge and literature related to the project. It consists of information on regulations, a brief chapter about the history of packaging, reports on current innovations, and insights from expert interviews. The topic "packaging at Oslo Airport" covered the information given beforehand by Avinor about the packaging waste at Oslo Airport and insights from the visits to Oslo Airport. The topic "eco-impact of packaging" covered packaging from an environmental perspective through literature and LCA analysis. These chapters together formed a base for the direction of the concept development.

Define (Chapter 7)

The second phase was called define. In this phase goals for the concept and the design goal were defined more specifically. Another important step in this phase was defining the influence airport operators have on packaging decisions and where there is an ability to improve in the short term. This was done through an impact model and through setting goals for the problem areas that came from the discovery phase. Through this, a focus area for the concept was defined. At the end of this diamond, a design goal was set.

Develop (Chapters 8, 9,10)

In the third phase, the concept for 2030 and the roadmap were developed based on the outcomes of the previous phases. Both were tested during the third and final visit to Oslo. This phase also included the development of interventions and design directions to inspire future packaging developments at Oslo airport in the long term through a roadmap.

Deliver (Chapter 11,12,13)

In the last phase, the Roadmap and the final concept were finalized based on feedback that was gathered during visit 3 through interviews and testing. In this part of the report, the final results were presented.

Methods & Tools

Throughout this research, multiple methods and tools were used to gather information and select concepts. These are explained in this chapter.

Literature & Desk research

During this project, literature related to packaging and circularity was read and integrated to get an overview of the packaging industry. This was done to gain familiarity with the background knowledge in the packaging industry and to identify already established barriers to the adoption of reusable/refillable packaging solutions. During this literature review, multiple themes came forward when looking into different aspects of the packaging industry;

- What is packaging and why do you use it
- Packaging from a historical perspective
- Eco-effectiveness of packaging
- Communication
- Sustainability in the packaging industry
- Transition to reuse solutions
- Existing reuse solutions
- Waste signage
- Co-creation as a tool for circular solutions
- Future developments

To find these studies keywords such as “reusable packaging”, “B2B reusable packaging”, “reusable transport packaging” “warehouse design” and “circular packaging” were used. Based on information in the abstract and conclusion section, 22 articles were read fully and this led to 10 more articles being added to this selection via the references of the articles. In total, 32 articles were used in this graduation project.

Expert interviews

Different experts in the packaging industry and airport warehouse/logistics were interviewed to gather more information to aid the development of this project. Table 3 shows the different interviews that were held, the goal, and the duration of these interviews.

Observations

To gather insights into the supply operations and return operations at Oslo Airport multiple observation sessions were held at Returpunkt 19 (Rp19). RP 19 is the main waste station at Oslo airport and the point at which goods come in and where reusable packaging is gathered to be taken back by suppliers. For this, an observation table template was used to structure insights and guide the observations. This outcomes can be seen in Appendix C. Table 4 shows the location, length, and goal for each of the observation sessions.

Stakeholder mapping

Stakeholder mapping was used in this project to show how the relationships between different packaging stakeholders are structured. Due to the complexity of the packaging industry visualization of communication streams can help identify where the communication from one stakeholder to another reaches.

#	Expert	Goal	Location & date	Time span
1.	Packaging expert	Gain initial insights in innovations in the packaging industry, in what extend packaging desicions can be influenced and how a project related to packaging is approached.	KIDV, 19/3/2024	70 minutes
2.	F&B operator 1 environmental representative	Gain insight into their sustainability agenda and activities in the packaging sustainability topic.	Online, 15/4/2024	60 minutes
3.	F&B operator 2 environmental represenative	Gain insight into their sustainability agenda and activities in the packaging sustainability topic.	Online, 19/3/2024	60 minutes
4.	Supplier 2 packaging represenative	Gain insight into their sustainability agenda and activities in the packaging sustainability topic. Know why they supply products in certain types of packaging. (Why are they not all supplied in re-use solutions?)	Phone call, 15/4/2024	30 minutes
5.	Supplier 1 environmental representative	Gain insight into their sustainability agenda and activities in the packaging sustainability topic. Know why they supply products in certain types of packaging. (Why are they not all supplied in re-use solutions?)	Online, 2/5/2024	60 minutes
6.	Security company employee	Gain initial insights on the warehouse logistics	RP19,	30 minutes
7.	Interview rounds with tenants	Gain initial insights on reuse options that are used and milk usage.	Oslo Airport	60 minutes
6.	Security company employee	Gain initial insights on the warehouse logistics	RP19,	30 minutes
8.	Supplier 3	Gain insight into their sustainability agenda and activities in the packaging sustainability topic. Ask for options for bulk deliveries and LCA analysis of their beverage cartons.	Online, 13/6/2024	25 minutes
9.	F&B operator 1 Food and beverage station representative	Get feedback on Roadmap	Online, 12/6/2024	25 minutes
10.	Avinor representative	Get feedback on Roadmap	Oslo Airport, 10/6/2024	30 minutes
11.	F&B operator 1 Warehouse representative	Get feedback on Warehouse concept	Oslo Airport, 10/6/2024	35 minutes
12.	F&B operator 1 environmental representative	Get feedback on Roadmap	Oslo Airport, 11/6/2024	30 minutes

Table 3: expert interviews overview

#	Observation location	Goal	Date, time
1.	RP19	Initial exploration of goods flow	1/3/2024, 9:19-10:00
2.	RP19	Get insights into incoming supply routes and suppliers.	10/4/2024, 8:00-8:45
3.	F&B operator 1 central kitchen	See the types of packaging for foods, how they are handled & what suppliers are used	10/4/2024, 14:00-14:20

Table 4: Observations overview

Co-creation

During the second visit to Oslo a co-creation session was held. Co-creation is very helpful tool for designers to develop a deeper understanding of the needs of the target group. Co-creation methods enable users and other relevant stakeholders to participate in the design process of new service and product offerings (Holmlid et al., 2015).The session was combined with another graduation project at Oslo airport, with a different topic. This was done due to limited time availability of stakeholders. The co-creation session took 90 minutes (from 9:00 until 10:30) and was held in an office above the check in counters at Oslo airport. The different participants were:

- F&B operator 1 environmental manager
- F&B operator 1 tenant worker
- F&B operator 1 warehouse representative
- Avinor representative
- F&B operator 4 tenant worker

The session was overlooked by two creative facilitators (the two graduation students). The session was split into different phases with different assignments and exercises;

- Problem defining
  - Problem presenting
  - Icebreaker
  - Purge
  - Hidden presumptions
  - How 2s
  - Hits
- Idea finding
  - Interactive sketching
  - Hits & dots
- Solution finding
  - Presentation

Figure 6 shows an impression of the set-up of the session. The results of the co-creation sessions and set-up can be found in Appendix B.

Figure 6: impression of the set-up.

Life cycle analysis

Life cycle analysis (LCA) is a framework that assesses the comprehensive environmental impacts of a product, system, or service over its lifetime (Pruitt et al., 2021). This was therefore a useful tool to apply in the define phase of the project to identify where the reduction of packaging could result in a significant environmental footprint reduction.

Brainstorming

To come up with ideas for possible solutions to the problems identified at Oslo airport brainstorming sessions were used to spark creativity. Brainstorming as a method prescribes a specific approach with rules and procedures for generating ideas. It is one of many methods used in creative thinking to come up with lots of ideas to solve a problem (Van Boeijen et al., 2013). This was used at the beginning of the idea generation phase in combination with how to questions to get to initial ideas.

Weighted objectives method

To come to the focus area for the final concept, the weighted objectives method was used. This method is an evaluation method for comparing design concepts based on an overall value per design concept (Van Boeijen et al., 2013). The Weighted Objectives Method is used when evaluating design concepts, and to decide which design concept should be developed into a detailed design. For this method, you set certain criteria. The concepts are evaluated in the way they fulfill these criteria. Some concepts score higher than others and in this way, you can look into what concept fulfills the needs most and choose the most relevant concept to move forward with.

Storyboards

A storyboard (see Figure 2.34) is a valuable aid to the designer, because it provides a visual description of the use of a product that people from different backgrounds can ‘read’ and understand. A storyboard not only helps the product designer to get a grip on user groups, context, product use and timing, but also to communicate about these aspects with all the people involved. This technique was therefore used during the testing phase of the project, to present the concept, so valueble feedback could be gathered.

Design Roadmapping

A roadmap is one of the end deliverables of this project. By design roadmapping creative responses to future strategic challenges can be devised. Guided by future foresight techniques, you uncover new trends, scout for new technologies, and map the values and ideas on the roadmap. Through strong visualisation, a design roadmap supports an organisational mindset on value innovations (Simonse, 2018). In this project it is applied by indicating problem areas, future visions, potential future innovations, and barriers for the adoption of certain packaging innovations .

Phase 1

D I S C O V E R

The Packaging Industry

This Chapter focuses on the background of the packaging industry. It states information from relevant literature and summarizes key insights from expert interviews.

Literature Research

What is packaging and why do we need it?

To better understand the design challenges concerning sustainable packaging existing literature regarding the packaging industry was explored. First off, it is important to define different types of packaging. When we talk about packaging, we can talk about different layers of packaging, such as primary, secondary and tertiary (Meherishi et al., 2019) , see Figure 7.

Figure 7, example of primary, secondary, and tertiary packaging

These types of packaging are used in different stages of the supply chain and have different uses. But packaging is also needed and designed with different attributes in mind. Literature states that packaging is useful because it provides "a system that enables the safe, cost-effective and efficient storage, handling, transportation and marketing of goods along the supply chain" (Meherishi et al., 2019). The main attributes of packaging namely; providing protection, handling ease, and branding are therefore important to keep in mind while (re)designing packaging. Lockamy (1995) divides this up even further, naming six main functions of packaging; 1) containment, 2) protection, 3) apportionment, 4) unitization, 5) convenience, and 6) communication.

With packaging having such a wide influence on different parts of the supply chain and product, assessment of packaging is more complex than assessment of other product groups (Svanes et al., 2010). It has a 'double' environmental impact that is evaluated through system enlargement, where the packaging system and the product system are seen in combination (Svanes et al., 2010).

Packaging regulations

Norway is not part of the EU but is part of the European Economic Area (EEA) and the European Free Trade Association (EFTA). Thus they comply and have a commitment to harmonizing with packaging regulations that are set by the European Union, but they also have their own additional regulations. There are lots of rules and regulations surrounding packaging in the EU. A specific development In the packaging industry is that on the 30th of November in 2022 the European Commission proposed the Packaging and Packaging Waste Regulations (PPWR). The PPWR updates the EU legislative framework for packaging and packaging waste by giving member states and businesses adequate support to achieve waste reduction targets. This is done with a harmonized regulatory framework that reduces waste, supports investment, and promotes high-quality recycling (European Commission, 2022). The final version of the PPWR is expected this year, 2024 and implementation could start in 2025.

The PPWR applies to all EU-based companies and companies importing packaging to the EU, meaning it has a big influence on the packaging used in the whole of the EU. With extended producer responsibility (EDR), the EU wants to incentivize the use of recycled packaging and give a financial incentive for more eco-friendly packaging. Mandatory recycled content targets for material use are also set with these regulations, because right now post-consumer recycled content often goes unused, mainly for financial reasons. Taking a look at the Norwegian waste regulations, we can see packaging being defined as:

"packaging means all products and disposable items, made of any materials of any nature, to be used for the containment, protection, handling, delivery from the producer to the user, and presentation of goods, including raw materials and processed goods." (Norwegian Environment Agency, n.d.)

In the Norwegian waste regulations, different duties are highlighted in regard to the composition of packaging and handling of packaging waste. There is a duty to ensure waste prevention and to report on the waste prevention efforts by producers. This is done via an annual report with an overview of action taken, expertise available, and information activities. It also describes changes in the quantity of packaging generated by weight in tonnes and the percentage change from the previous year, and further plans for waste prevention. Moreover there is a duty to report the total quantity of packaging waste collected, treated, and transported onward for different types of disposal and a duty to report the overall recycling rates for packaging waste (Norwegian Environment Agency, n.d.).

Some requirements have to be satisfied relating to the re-use of packaging in Norway. The physical properties and characteristics have to enable it to be re-used a number of times under normally predictable conditions of use, it has to be possible to treat used packaging per the requirements of employees' health and safety and the packaging has to fulfill the requirements for recyclability when it is no longer re-used (Norwegian Environment Agency, n.d.).

These regulations mean there is a large focus on waste prevention (in volumes) for producers, leading to more circular packaging alternatives being considered and possibly introduced. The duties also apply to Oslo Airport and Avinor. They have and comply with the new rules and need enough capacity to store enough return items.

Packaging from a historical perspective

Understanding the history of the past can be a base for designing the packaging of tomorrow. Packaging design choices are drastically influenced by different factors. These could be, the environment, the economy, handling, and even more. With the evolvement of new technologies packaging has changed drastically over the past decades.

Long ago, the food and products that were consumed were local, meaning transport routes were short (Hook & Heimlich, 2017). When packaging was needed, this packaging was taken from nature, think of shells and leaves. Containers could be made out of natural materials such as woven grasses (Hook & Heimlich, 2017). Later on, methods like pottery were developed. Paper can be seen as the oldest re-shapable packaging and originated in China (Hook & Heimlich, 2017). The technique reached Europe in 1310. The first cardboard box was produced in 1817, replacing wooden boxes in trade (ASD Turkish Packaging Manufacturers Association, 2020). Plastic can be seen as the newest material form of packaging, it began to be widely used after the 1950s (Hook & Heimlich, 2017). The use of certain materials for packaging is essential because otherwise the product transported might not be able to make it to the place we need it to go to. Plastics are for instance essential to preserve certain goods to get them to their end destination (Lockamy, 1995).

Large refill systems used to be in place for milk, wine, and other beverages, but as single-use packaging was optimized and introduced this became the more cost-efficient option and it was a way of differentiation for brands. Currently, it is only still used in countries with deposit systems (Feber et al., 2022), a visualization of innovation in the milk packaging industry can be seen in Figure 8. However, today we see a countermovement in consumer behavior where environmental impact is an important factor in purchase decision making. 43 percent of consumers find this extremely or very important. Consumers are also willing to pay more for sustainable packaging (Feber et al., 2023).

Packaging and sustainability

This importance of sustainability was also highlighted in more literature related to supply chain management. With the world moving rapidly toward sustainability by adopting sustainable practices in its processes, it is important for supply chain management to adopt sustainability. This has to be done in operational aspects, logistics processes, and strategic decisions to stay competitive with the global shift toward sustainable development (Asim et al., 2022). Moreover, unsustainable packaging can be seen as a threat to sustainable development and ultimately to the development of a circular economy (Abad-Segura et al., 2020). Companies are also encouraged to incorporate strategies for green packaging in their process either due to customer demands or regulations imposed by authorities such as the European Union. The EU does this by demanding members to take steps toward introducing packaging waste management systems (Asim et al., 2022).

Existing reuse solutions

While research on reuse packaging in the field of B2B (business-to-business) solutions is still in progress there are various very well-developed B2B solutions on the market already. The most applied B2B solutions currently are re-usable pallets, re-usable big bags, and re-usable crates for goods delivery. Some examples can be seen in Figure #FIXME. These solutions are widely applied, mostly because of financial reasons, but more and more also because of the environmental benefits these solutions offer (KIDV, 2021).

Other sustainable developments in the packaging industry include reusable pallet wrapping, digital labels, reusable shipping bags, and hand soap powders. These examples have been summarized in Figures 9 and 10.

Measures to eliminate packaging usage are also being taken in the aviation industry. For example in August 2019, San Francisco airport became the first airport in the world to prohibit the provision or sale of single-use water bottles in plastic or aseptic paper packaging. This policy has now been expanded to prohibit the sale of any beverages, including sodas, teas, and juices in plastic or aseptic paper packaging (Flysfo, 2021).

Figure 8: evolution in the milk packaging indusry from a historical perspecive, retrieved from https://www.digimarc.com/resources/stories/history-packaging

Figure 9: existing B2B reusable packaging solutions in the packaging market

Figure 10: circular innovations in the packaging market

The B2B pooling system

There are different types of existing reverse logistics models for reusable packaging; a B2B pooling system, a B2C pooling system, an independent B2C infrastructure, and a 3rd party-dependent B2C infrastructure (Ministerie van Infrastructuur en Waterstaat, 2023). The reusable packaging that is within the scope of this project falls into the B2B pooling system category. The characteristic of this category is that it is a rotating pool of standardized assets and is owned by one party (the system operator). The items are transported by a logistical party. Moreover, the items are highly efficient due to foldability when empty for efficient use of space and because they are transported back with existing logistical streams. Implementing a B2B system requires an adaption in the supply chain and the incentive of return is a deposit. The tracking technology, if the system has this, is a barcode and/or QR code (Ministerie van Infrastructuur en Waterstaat, 2023). Figure 11 shows the example flow of existing B2B pooling systems.

Transition to reuse solutions

Currently, there is a lot of research on the waste management of reusable packaging, however, there is an absence of studies that delve into what a transition to circularity would actually require (Nilsson et al., 2011).

According to an article by Gruenewald et al. (2023) the impact of reusable packaging will depend on execution and behavior, some key questions to address are;

- How many use rotations are needed before emission reductions are reduced?
- What is the average distance reusable packaging will travel?
- What recycling rates can be achieved?
- What adaption to operating models will be required?

The first questions relate to how the circular option might not always be the most sustainable one if we look at emission reduction. Therefore it is important to keep in mind what the rotations, distances, and recycle rates are. The last question relates more to the human aspect of changing a certain system. When solutions are implemented, the question that still always remains is whether daily behavior also adapts. The conclusion can be derived that the easier that reusable items can be returned, the easier a reusability circle can be maintained (Gruenewald et al., 2023).

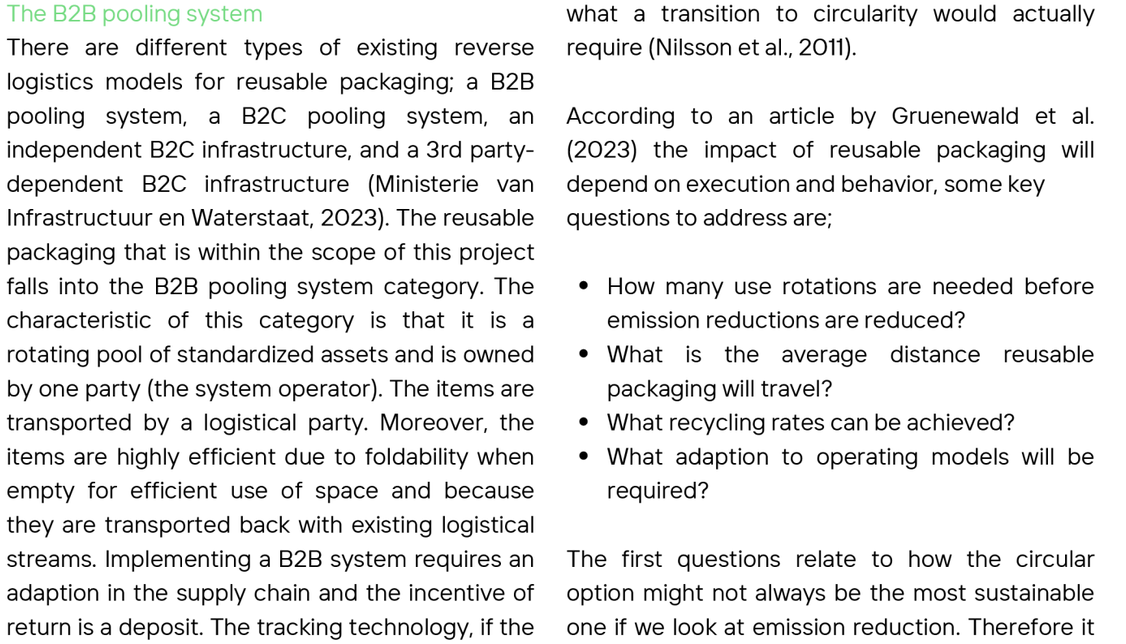


Figure 11: B2B pooling system, retrieved from (Ministerie van Infrastructuur en Waterstaat, 2023)

It can be beneficial to have a guide to help design holistically when designing for the packaging industry. To help with this and move towards sustainable good flows from a packaging perspective a paper by Nilsson et al., (2011) poses a framework, as seen in Figure 12, which takes into account financial, environmental, and social aspects. Since this framework accounts for different aspects of sustainable development, it can be useful to evaluate and identify opportunities in different contexts and help tackle packaging problems.

Figure 12 (Nilsson et al., 2011), a framework to move towards sustainable goods flows from a packaging perspective

Compared to secondary and tertiary single-use packaging there are multiple identified advantages to reusable secondary and tertiary packaging. These secondary and tertiary reusable transport packaging solutions improve workers' safety and ergonomics, because (1) their material and design reduce or eliminate injuries due to box cutting, staples, and broken containers, (2) their ergonomically designed handles and access doors improve workers' safety, (3) their standardized sizes and weights reduce back injuries, and (4) they reduce the risk of slip and fall injuries by removing in-plant debris. Reusable transport packaging also provides just-in-time delivery of the finished products, because it provides standardized ordering quantities which can improve ordering procedures and inventory tracking. In addition, it provides more frequent shipments of smaller quantities and offers deliveries close to the time of consumption which can reduce the number of days that dollars and inventory are nonproductive (Mahmoudi & Parviziomran, 2020). However, for those willing to adopt reusable packaging, options operations management is critical and complicated due to the high volume and frequency of deliveries/pickups (Mahmoudi & Parviziomran, 2020).

There is also a need for an ecosystem and regulatory framework beyond the country to introduce reusable packaging on a large scale (Feber et al., 2022). Since supply chains are increasingly longer it is needed to cooperate across countries to standardize our reuse options and coordination. This is complex to influence as a sole player, instead, it is needed to form partnerships along the packaging value chain to go toward successful implementation (Feber et al., 2022). Considering variations in transport distances, input for cleaning, and variation in the containers' lifespan, comparing reusable solutions to single-use counterparts is difficult to carry out and is thus relatively scarce (Accorsi et al., 2020). This means it is difficult to convince stakeholders to take part in the transition toward a circular economy since benefits cannot be clearly seen/understood (Accorsi et al., 2020). Another article identified more barriers to the adoption of reusable packaging solutions in different categories. The insights applicable to this project are summarized in figure #FIXME. An additional identified barrier to the adoption of reusable packaging in the food & beverage industry is that reusable packaging will likely struggle to be inclusive to those with severe allergies (Ellsworth-Krebs et al., 2022).

As previously mentioned, the packaging industry is complex with its long supply chains. A main insight from literature is that innovation and research should be done in collaboration with stakeholders (e.g. producers, trade, retail, logistics) in the various supply chains to get to

realistic insights (Nilsson et al., 2011). Partnership and cooperation have been identified as key considerations for CE organizational operations (De Sousa Jabbour et al., 2019). Collaborative initiatives are also proven to result in better environmental and economic outcomes (Flygansvær et al., 2018).

Interview insights

Interviews were carried out to come to an understanding of the packaging industry. The full interviews with the insights annotated used in this chapter can be found in Appendix A. This paragraph will state the most important insights.

The packaging world is very complex and during interviews, it was emphasized that it is very hard to make a difference in long and international supply chains. The longer supply chains make it almost impossible to have an influence, especially if you are not integrated into that company itself.

It was recommended by the employee of the KIDV to approach this mainly through policies for the supply of certain products for commercials. The smaller the supply chain, the easier it is to have an impact on packaging choices as a company such as Avinor.

Another insight from the interview with the KIDV was that most differences in packaging are made because of new regulations that are being imposed by the EU. With the new PPWR regulations in mind, it is very useful to set goals in the long term and make policy alterations because it requires companies to change parts of their operations.

When collaborating throughout the supply chain or a hub such as an Airport, we can learn from each other and reuse each other's packaging to establish a more circular environment.

Barriers for the use of reusable/refilllable packaging solutions

LOGISTICS	COST	HYGIENE/FOOD SAFETY/QUALITY	CONVENIENCE	ACCEPTENCE
Reverse logistics can be complicated	Reusable packaging is typically more expensive than single use packaging	Recycled material must be food grade for specific uses	Willingness to return is limited with consumers	Standardized packaging can conflict with brand differentation
Food and beverage containers often bulky to transport	Investment-space and labor are needed for collecting and washing packaging	Quality assurance and consumer trust are key	It takes time and efford to refill packages, limting broad scaling	There is a lack of incentives for cosumers and producers
In terms of total life cycle assesment long distance transportation is high in CO_2 emissions	Brand owners desire packaging variety	Food residues can attract pests and vermin at collection points	Refillable solutions are only applicable for certain product categories	The complexity of supply chains is increasing
Rules on food safety for bulk distribution apply	Cost to consumer is lower for refillable packaging, but margin acceptence by retailer is potentially in question	Food-grade refillable packaging is more difficult than, say, soap containers, as they require better containers and consumer education to use correctly		Multilayer pouches fueling the current refill trend are not fully sustainable
				Self refilling requires efforts

Figure 13, Barriers for the adoption of reusable/refillable packaging solutions according to Feber et al., (2022).

Key Insights - The packaging industry

- The PPWR will cause disruptions in the packaging industry and will make packaging to have to be made more sustainably in the coming year/years
- Providing protection, handling ease and branding are the main attributes of packaging
- Single-use packaging is currently seen as the most convenient and cost-effective form of packaging
- Environmental impact is becoming an increasingly important factor in purchasing decision-making for companies
- Packaging manifests potential for sustainable growth
- The packaging industry is complex due to its long and invisible supply chains and the varying needs of stakeholders
- Partnership and cooperation have been identified as key considerations for change in the packaging industry and this also leads to better environmental and economic solutions
- Supply chain management needs to adapt sustainability in their operational aspects and logistics processes and their strategic decisions to stay competitive with the global shift toward sustainable development
- There are different barriers to the adoption of reusable/refillable packaging solutions related to logistics, cost, hygiene, convenience, and acceptance

Packaging at Oslo Airport

This chapter will focus on packaging at Oslo airport. It will start with information about packaging waste and exemplify the current situation at Oslo airport. Afterward, it will go into outcomes from observations at Oslo Airport in the different shops and at the waste station.

Oslo Airport and tenants

To know to what extent Avinor can influence a company's sustainability practices it is needed to understand how Avinor works with the different commercial units.

Before moving in, tenants must comply with environmental requirements, including circularity regulations. They need a strategy to minimize waste and practice environmental management. There are certain evaluation requirements set by Avinor, the better they perform, the more chance they get a contract. The contracts run for five years. Multiple new tenants will move in again in 2025 since some of the last contracts were supplied in 2020 (some contracts are not in line, such as Shop 1, and some food and beverage stations).

After moving in they receive an operation management document with “house rules”. Avinor is also preparing an onboarding package for circularity, posters learning materials, and guided tours, which they want to provide in 2025. They also have follow-up rounds on contracts. In general, communication currently happens through Key account managers higher up. However, Avinor wants to slowly move towards direct communication with tenants, wanting each unit to have a person responsible for environmental issues.

Right now, we are heading for a natural moment of change at the Oslo airport terminal. Contracts of multiple tenants are ending, and because of this new contracts will be signed, meaning there is a possibility to apply more strict rules concerning sustainability naturally within these new contracts for tenants.

The commercial units are either independent or are part of a larger operator (eg. F&B operator 1, F&B operator 2, F&B operator 3). Avinor assigns the commercial unit spots to the operator or independent commercial unit. This means that many of the commercial units operate in the same way. How the commercial units are divided can be seen in confidential Appendix I.

Waste statistis and logistics

From the waste statistics of Oslo airport in 2023, the rough numbers of packaging waste in 2023 were derived (kg/year);

- 661 340 kg paper. Mostly cardboard or cartons related to packaging or goods delivery
- 183 775 kg wood – half of it is single-use wooden pallets, used in goods delivery.
- 14 721 kg plastic packaging foil, used exclusively in goods delivery
- 70 000 kg of milk cartons

There is an unknown amount of packaging waste in residuals due to improper source separation. Avinor estimates that at Oslo airport a few hundred tons of packaging paper and plastic packaging end up in residual waste in a year. Oslo Airport has multiple waste stations at different locations. They are located underneath the arrival hall and their approximate entry points (by elevator) are indicated in Figure 14.

Returpunkt 20 & UNSØ

At Returpunkt 20 (Rp20) only 12% of waste is collected and it's mostly used for waste generated by construction companies. RP20 uses the same signs to indicate waste separation

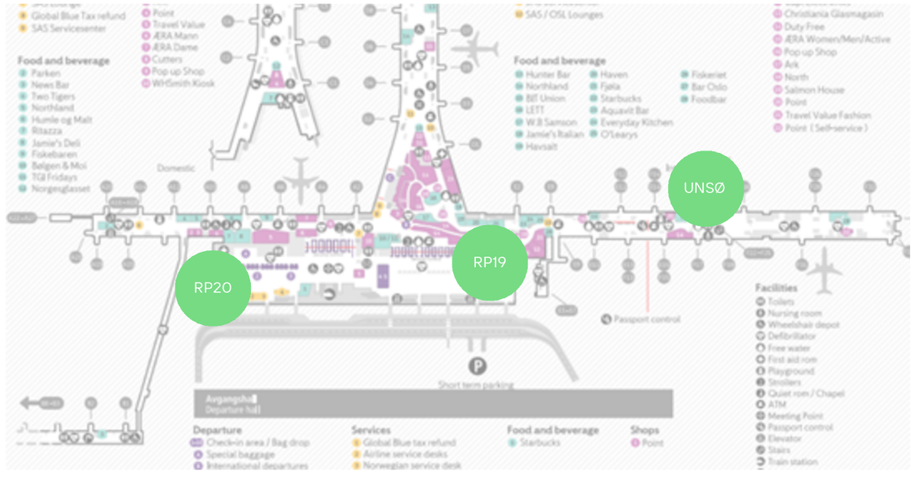


Figure 14: entry points waste stations

but offers additional possibilities like porcelain.

Waste station 3, named UNSØ is located underneath the international departures hall, an image of this waste station can be seen in Figure 15. However, it is small and only used by a few tenants, about 2% of waste is collected here.

Moreover, there is also a waste container located further into the departures hall, for tenants who are located far out and have to walk a long time to reach Rp19, but usage is discouraged since there is no waste separation and it is not an official waste station.

Figure 15: waste station “UNSØ”

Returpunkt 19

Returpunkt 19 (Rp19) is the name of the biggest waste station and this station is used most. This waste station is where waste from the different commercials is thrown away. It can be accessed through an elevator from the departures hall and is located underneath the arrivals hall. At this waste station, 85% of waste is collected. It is also where goods come in for delivery and the return order area is located in this waste station. At the return order area, different reusable packaging and return orders are stored for return logistics.

There are also multiple containers in RP19 and waste streams are displayed using icons and text, see Figure 16. On these boards, the color of the waste stream is displayed. It starts with the Norwegian name of the waste stream, then an English translation. It shows what to put into the container and what not to put into the container. It also uses check and cross icons with corresponding green and red coloring to indicate the distinction between what should go in the container and what should not.

After visiting Rp19, a map of the waste station layout was established, which can be seen in Figure 17.

One key takeaway is that products for commercial activities are supplied at Rp19 and waste and reuse options are also disposed of in Rp19, which is why observational research is most useful to be carried out in this area and this station will be the main focus of the graduation project.

Figure 16: examples of information boards at Rp19

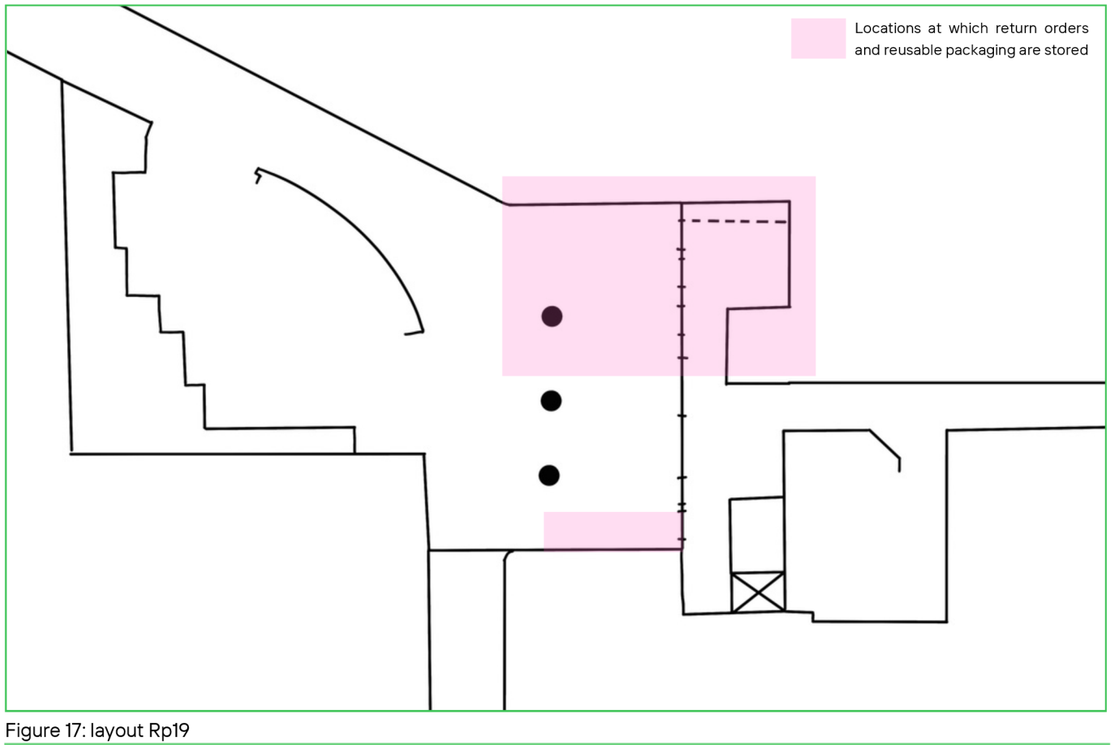


Figure 17: layout Rp19

Return orders area and waste sorting at RP19

Currently, Oslo airport has already installed an area in RP19 for reusable packaging and other return orders, an impression can be seen in Figure 18, and the area is located inside Rp19. The return options in the return area are indicated with handwritten signs on cardboard or with laminated paper signs.

Re-use packaging solutions collected in this area are;

- Reusable pallets (grey plastic pallets and EPAL pallets)
- Milk crates & carriers
- Transport crates from supplier 1
- Green and black transport crates from supplier 2 (vegetables and fruits)
- Kegs
- Beverage crates
- Water jugs (18,9 liters)
- Other metal carrier crates from unknown suppliers

A visual overview of reuse solutions and pick-up frequencies was established in collaboration with the security company can be seen in Figure 19.

The return of reusable items works as follows; waste and reusable items are disposed of in tenant shops by tenant workers, and then it is brought to the waste station, either by workers from F&B operator 2/supplier 1/shop 1 or by the tenant workers themselves. Therefore the problem arises that when there is a lack of knowledge on the tenant workers' side, it is sorted wrong and is put in another waste stream, even though it is reusable. The same could happen when a warehouse worker is unaware of the different reusable solutions. The current signs of the locations at which to return packaging currently do not stand out and are unclear.

During the first interview with the security company that oversees RP19, see Appendix A1 it was mentioned that one of the problems with the current re-use options is the lack of awareness of where to put certain items by warehouse workers and tenant workers.

This was affirmed by the observation that during all visits plastic milk carton carriers, that are reusable, were found in the mixed plastic container, see Figure 20 instead of sorted correctly in the return area.

Moreover, during multiple conversations with the security company, the stereotype arose that the workers were in a hurry and did not want to make the detour to the return area. Resulting in them putting the products back in the wrong place.

One of the most noticeable items in the waste bins at Oslo airport is the milk cartons. They can be clearly seen due to their bright pink color (Figure 21). and they are estimated to generate about 70 tons of waste per year by Avinor.

Figure 18: reuse area

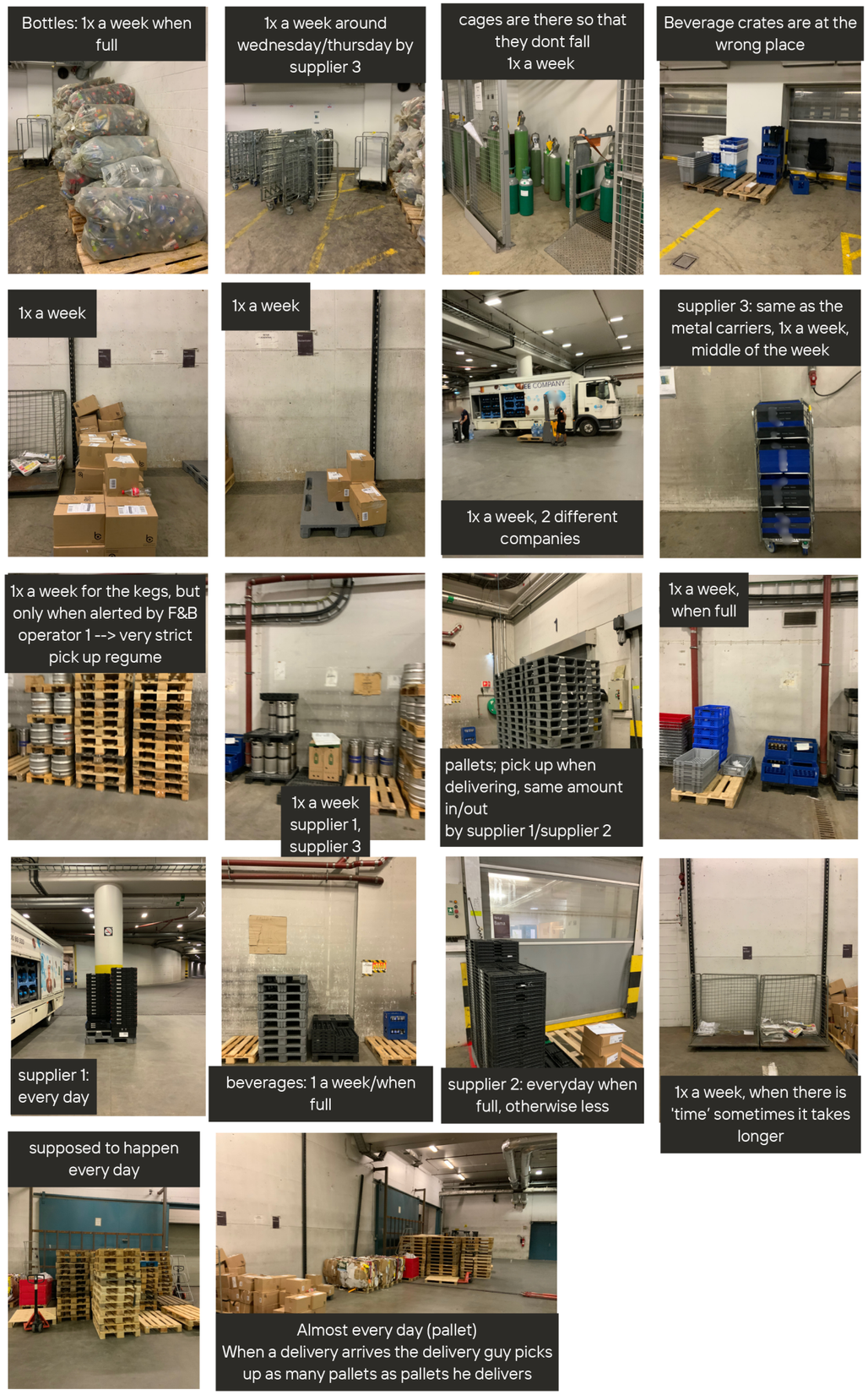


Figure 19: Outcomes research return items/packaging pickup

Figure 20: reuse area

Figure 21: milk cartons in the wrong waste stream

The milk cartons can be seen in Figure 21. The milk cartons are disposed of incorrectly at times, which was seen through observations at the terminal and inside the waste station.

Furthermore, packaging waste issues related to cardboard have been identified. The waste station has two dedicated waste containers for cardboard because it is disposed of in such large quantities. The waste is picked up on weekdays, so during the weekends, the cardboard waste causes the containers to overflow. Although the containers have a built-in compressor, it is not widely used by employees (reason unknown), resulting in rapid overflow of waste. Additionally, cardboard is sometimes disposed of incorrectly, as shown in Figure 22, where cardboard is found in residual waste.". The amount of cardboard waste also poses as fire hazard, which the fire department is concerned about.

During these observations at the waste station, it was questioned whether there is even enough area in the storage space to introduce more return orders. With the area there is now, it would become a logistical challenge.

Therefore an additional challenge is to make sure there is enough space for new return orders. Moreover, if all packaging has to become circular at some point in the future, there would be an even higher amount of packaging items that would need to be stored.

It was also identified that all the existing return orders seem to be all local, Norwegian products. .

Figure 22: reuse area

Supply journey flow

Through observations of supply operations and interviews with Security company employees (appendix A2), a product flow map for regular supply (supplier 1/2/3 or other) was created (see Figure #23), as well as a map for supply operations of shop 1 (see Figure 24).

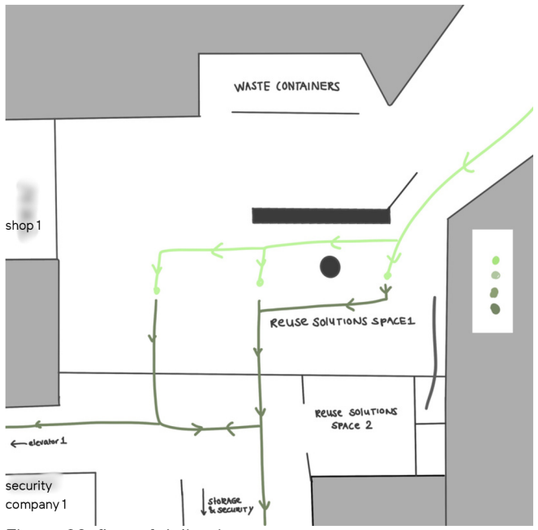


Figure 23: flow of deliveries

The light green lines of both Figures 23 and 24 resemble the trucks coming into the warehouse, they park at the end of these light green lines. For Figure 23 the flow is as follows; the products are taken out of the truck by warehouse workers and taken to a supervisor, who checks for an "ok" sticker. The flow of this is pictured by a dark green line. If this sticker is on the delivery, it means the shipment was pre-approved and that the products do not have to go through the security X-ray scanner. The airport has certain suppliers who are approved to do this and this saves time and effort on their side. Thereafter the products are taken to the storage of shops or they are placed back in RP19 for pickup by commercials who manage their supply themselves.

Shop 1 operates by itself and has its storage separately from other units. In Figure 24, the light green lines also resemble the trucks. Their products can go immediately to their storage or to their shops, no extra security is needed.

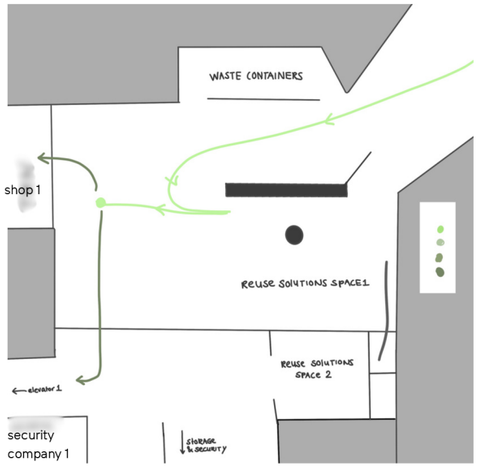


Figure 24: shop 1 flow of deliveries

No pictures were taken of the security checks or shop 1 operations due to restrictions.

Moreover, a map of where return orders, and thus also reusable packaging are stored for returns was established, which can be seen in Figure 25. However, during all observations, the way these items were stored differed slightly. This might be due to unclear signage, lack of space, and unclear instructions. In Figure 25, the storage spaces for return orders are indicated with green blocks, either dark or light green. The difference between the two green colors is that the dark green spaces block important entryways.

Sometimes the marked areas were empty. Since return orders are picked up frequently, the amount of items that have to be stored differs daily.

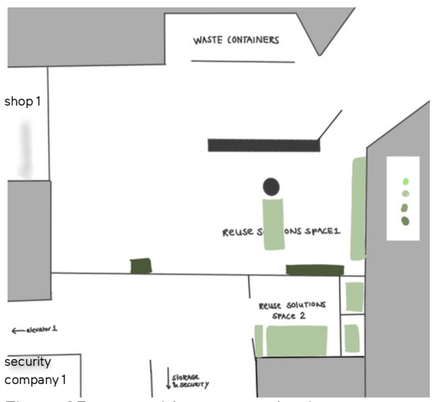


Figure 25: areas with return packaging

The previous insights about transport routes combined with insights from conversations with a security company worker, see Appendix A2, and observations, see Appendix C, give insights into why the return area is structured in the way it is now. The trucks have to reverse in certain areas of the warehouse and have to be able to park in between the different poles in the warehouse, these poles are visualizes as black dots in Figure 26. The only places the reuse options can be stored are where they are now, as that is the only area left that does not interfere with the goods flow. To come to a more concrete picture of areas that need to be kept free during operations a security company employee and warehouse representative from F&B operator 1 were asked to mark the areas in the reuse area for me that have to be kept free. This can be seen in Figure 26.

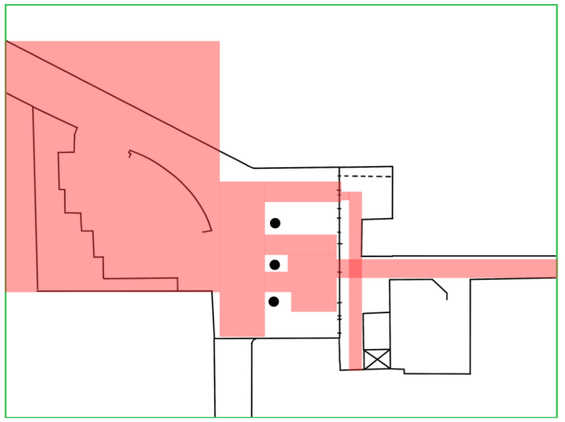


Figure 26: areas that have to be kept free marked in red

Signs at the return area in RP19

When walking through the reuse area there are different signs already in place. Many of these are printed and some are written, the signs can be seen in Figure 27. The source of the different signs was not uncovered, however, some signs have been there for a long time, according to the security company and the warehouse representative of F&B operator 1, the sign at the bottom right has been there for more than 5 years and it says "How hard can it be? 5 carriers on top of each other". Further, on the top right, there is a sign indicating where supplier 2 and supplier 3 returns have to go with an arrow, indicating that

Figure 27: signs at the reuse area

warehouse workers have to enter the alley to the right to get there. This sign is however very small and hard to see from far away. The sign is made from laminated a4 paper and put there with tape. There is no coherence in the signs that are currently in place in the return area in RP19 and they are placed on different heights. There are also some markings on the ground, but they are worn away and not used, see Figure 28.

Figure 28: markings on the ground

Insights interviews

Lack of attention

During conversations with the security company, it was mentioned multiple times that packaging solutions were not sorted correctly due to a lack

of attention. They saw that signs were not read. An example was mentioned of a sign on which it was written that steel was prohibited in the container beneath it. However, the sign was not read fully and warehouse workers had put a lot of steel in the container. This was an important insight that shows the importance of the first impression of signs and carefully reading the signs.

Logistics of return packaging

By talking to the security company and warehouse personnel the logistics of the return packaging was uncovered.

For different return items different systems are in place, but from interviews it is possible to derive that the logistics are roughly the same as in Figure 11 from the B2B pooling system. There are deposit systems and barcodes in place for plastic pallets and kegs. When products are delivered the same amount of reusable pallets and wooden pallets are taken back. The other items, such as the beer barrels get picked up when there is an order to pick them up from the supplier. This way they keep track of where their reusable packaging solutions are. For the EPAL pallets, no barcode has to be scanned, but there are deposits on the pallets.

Waste sorting

According to the security company employees, there are problems with packaging sorting. The waste handlers do not take the time to sort products correctly and the tenant workers are disconnected from the process in the waste room. There is a need for efficiency and clarity on where waste should go.

Height difference

Warehouse workers also mentioned that one of the struggles the delivery workers have from different suppliers is that there is a height difference between the trucks and the ground, see Figure 29, and there is no ramp at the warehouse. designing a solution ot this problem is outside of the project scope, as it does not

Figure 29: height difference between the van and the ground

decrease packaging waste, but it does cause discomfort for different suppliers and decreases efficiency, which is why it might be interesting for Avinor to look at.

Terminal interviews & observations

Food & Beverage

To get an overview of company operations from the different tenants the commercial units were visited during the course of two days during the first visit. Since time was limited and many units had to be visited the collection of data was limited to short questions and observations. These questions were asked to the people working in the food and beverage shops at the time of the visit. This included normal tenant workers and sometimes the managers of certain food shops who were working at the food and beverage station as they were visited.

The main aim of the interviews and observations was to uncover how widely some of the already existing circular packaging interventions are used, such as the crates from supplier 2 & supplier 1. Another question that was left was where the single-use pallets come from. It was aimed to uncover this by asking employees whether they get products supplied on single-use pallets.

Lastly, the tenants were asked what milk supplier they use, how many liters they go through each day, and for what purpose. The milk questions come from the identified problem of milk packaging waste. If every tenant or many use the

same supplier this could be a good option for a refill system. The detailed outcome of this research can be seen in confidential Appendix D, but some highlights will be noted now.

In Figure 30, the supplier 1 crates can be seen, while Figure 31 shows the supplier 2 crates, both of which were frequently discussed during the interviews. The visits revealed that the crates were often used for internal storage, leading to them not being returned to the supplier but kept by the food and beverage stations. This could potentially result in a lack of trust in the system, as distrust, due to the intractability of where an item is or was lost, was seen as one of the barriers to the adoption of reusable packaging by Ellsworth-Krebs et al. (2022).

Figure 30: supplier 1 crates at commercial unit

Figure 31: supplier 2 crates at commercial unit

Many tenants are supplied by F&B operator 1. If they are supplied by F&B operator 1 they get their storage delivered by F&B operator 1 warehouse personnel to their storage. This storage is located either at their unit or downstairs close to RP19. Some units also do not have a kitchen themselves and are supplied by a central F&B operator 1 kitchen, located underneath Everyday Kitchen in the international terminal, where the food they need is prepared. In these operations, a different kind of reusable crate is used. This is a transparent one in which the pre-made food is put, see Figure 32. This fits perfectly in the shelves/storage they have in the serving unit.

Figure 32: F&B operator 1 crates

To get a clear picture of where the milk carton waste comes various questions were asked about the milk supplier, how many liters are used, and what they are used for. If all tenants use the same supplier, it could be interesting to collaborate with the supplier on a possible refill system. Furthermore, if we know how much milk is used it is possible to estimate the progress that could be made in CO_2 eq if a refill system is introduced. Lastly, if milk is used for a coffee machine compared to hand-frothing milk it makes a difference. With a coffee machine, many liters are used in a matter of seconds and a refill system is applicable, compared to frothing by hand, where the milk has to be easy to pick up and thus a smaller packaging is more convenient. An example of milk storage and the way milk packaging is thrown away in large quantities can be seen in Figure 33, which features pictures taken during visitations of the commercial units.

Figure 33: milk carton storage & milk carton waste after filling up 1 coffeemachine

Many units use the milk to fill up coffee machines that have an average milk capacity of 6 liters. The machines are filled with 1-liter packages. Some units use 1,75-liter packages, but the 1-liter packaging was spotted more often during the visits. This means that there is a lot of waste created in a matter of seconds. A solution to minimize this waste might be the introduction of bulk buying or refilling. The milk brand that is used is the same in almost all commercials, supplier 3, a local Norwegian milk supplier. Local brands are often easier to contact and have smaller/clearer supply chains and thus present a greater potential for refill options. Therefore it is important to note that the milk is sourced locally There were also other local brands that could be seen at the units in large quantities. These were brands for coffee beans, various juices, and water bottles.

Shop 1

The Shop 1 shops are operated independently from other commercials. The headquarters and warehouse of the brand are located in Germany. They have their own cardboard compressor and waste management system at Avinor.

Insights from visiting shop 1 and talking to the employees of shop 1 during the first visit were that assembled deliveries packaged at their warehouse in Germany are shipped in cardboard boxes that can be folded and are quite sturdy. This is mostly done when an order is not complete or for cosmetics. They are often used for storage or taken by employees to reuse at home as they resemble the size and quality of moving boxes. However, they are also often thrown away. Shop 1 does not take the boxes back for reuse. This was noted as one of the biggest opportunities shop 1 employees see concerning their packaging waste, as these boxes are very fit for reuse.

Other goods like liquor and food come in the packaging supplied by shop 1's suppliers. These are cardboard boxes on EPAL pallets wrapped with plastic foil. They come directly from the suppliers and to change the packaging of these it would be needed to get into contact with these suppliers and shop 1 to evaluate different options.

Electronics & bookshops

At Oslo Airport, there are also multiple bookshops and electronics shops. The Electronic shops are owned and operated by Electronics 1, which is located in the Netherlands. Products come in from the headquarters and the most waste they generate is in cardboard packaging. These seem to be the main sources of waste and changing this would require communication with Electronics 1. Furthermore, a manager present at the store explained their interior and props come from China, so they sometimes come in on single-use pallets. This was the only lead that was found on the source of the single-use pallets at Oslo Airport. This means that not many people are aware of where these pallets come from and that it would need more research to uncover.

The Bookstore 1 bookstores have a storage room downstairs supplies are unpacked there. These supplier are brought to the stores in plastic reusable color-coordinated crates and each color is connected to one particular shop, so the stock does not get mixed up. The majority of books are supplied in single-use cardboard boxes. However, books from Norwegian suppliers, get delivered in reusable crates that are returned 1-2 times a year and used for storage otherwise. Bookstore 1 mostly produces cardboard waste except for some packaging waste from souvenirs that come in plastic packaging.

Interviews

During visits 1 and 2, some in-depth conversations were held with tenant workers at different food and beverage stations and shops. The main insights included that for workers in food and beverage shops, it was extremely important to have easy access to their products. During busy hours they need to make sure they can keep up with the demand. The products should also be easily transportable. Especially if the unit stores their products downstairs because this means they need to get the products themselves and thus it has to be easy and quick to transport for them as well.

It was also observed that there are forklift trucks available for use by tenant workers and different kinds of crates on wheels, as can be seen in Figure 34.

Figure 34: Examples of transport tools available

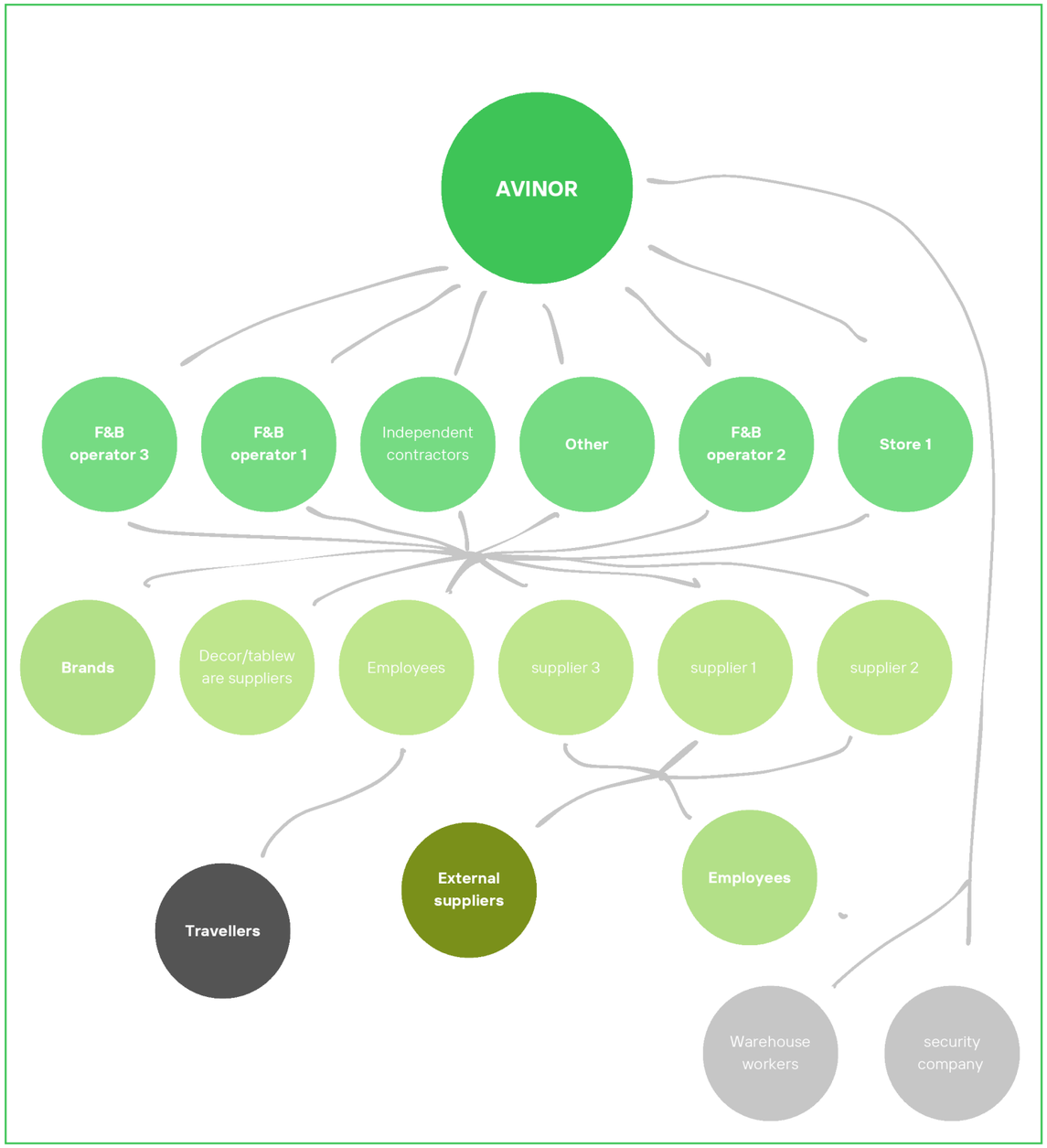


Figure 35: Stakeholder communication map

Stakeholder communication mapping

According to the information gathered during the visits, an initial stakeholder communication map was made. The stakeholder communication mapping can be seen in Figure 35. This mapping can be used to understand the communication flow between stakeholders. The mapping shows that the communication stream is quite linear and that Avinor is not in direct contact with the suppliers of tenants. This clarifies why it is difficult for Avinor to have an impact on Packaging decisions as information and demands from their side have to travel through various information flows before it is at the place where a change can be made, at the supplier.

Co-creation session

During the second visit to Oslo, a co-creation session was held. Co-creation is a very helpful tool for designers to develop a deeper understanding of the needs of the target group (Holmlid et al., 2015). Co-creation methods enable users and other relevant stakeholders to participate in the design process of new services and product offerings (Holmlid et al., 2015). The session was combined with another graduation project at Oslo airport, with a different topic. This was done due to the limited time availability of stakeholders. The full session plan, exercises, and outcomes can be found in section B of the Appendix. Figure 36 shows an impression of the session.

Figure 36: co-creation session at Oslo Airport

Insights

Participants grouped the established interventions, see Appendix B, into four different categories; design of the reuse space, the purchasing department (how to get packaging sustainability higher up the agenda), brand image (being a positive outcome of reaching packaging sustainability), and suppliers (as they influence packaging decisions according to the participants).

Moreover, both participants, an Avinor representative and an F&B operator 1 representative showed that they were aware of their role in the issue. Writing comments down such as “it starts with us”. However, they mentioned that they felt like their role in the issue was mostly in communication and pressuring other stakeholders to adjust their packaging towards more circular options. Finding concrete adjustments that could be made by them solely was difficult and they did not view themselves as a cause of the packing problem. It was insightful to see this since this was one of the struggles during this project. Similar to the research done for this project the extent to which we can improve packaging decisions on our own is limited.

Solutions proposed by the participants were to decrease the number of suppliers, use more reusable packaging, push suppliers to package in bigger boxes/volumes, get packaging waste reduction higher up the agenda, empower the purchasing department with knowledge on circularity, make a detailed roadmap for packaging free procurement, have the dedicated reuse area pimped up, to go towards refill options and to refuse to take deliveries when they are supplied in packaging that does not fit our goals.

Synergy between stakeholders was also mentioned as a key aspect of the issue by participants. The element of collaboration is essential in the process of going towards packaging circularity. This outcome complies with the outcome of the research.

A new element was the possibility of merging suppliers. The participants proposed that smaller suppliers would have to merge with a larger supplier such as supplier 1 or supplier 2 so they could package it together resulting in less waste and a smaller CO2 footprint.

Furthermore, there was a focus on concepts related to collaboration to solve the packaging problem during the session. Concrete redesigns for packaging, such as an alternative to single-use wooden pallets were not addressed. The concrete interventions that were mentioned talked about making the amount of deliveries smaller, by combining delivers or bulk buying. Outside of this co-creation session, it was also found that it is difficult to find a way to influence waste streams from larger and invisible supply chains of for example wooden pallets. Noticing how the main stakeholders also do not have insights into this affirms that eliminating packaging waste in its entirety is very complex and might even be undoable at this point in time.

Key Insights - packaging at Oslo Airport

- Currently, we are moving towards a natural moment of change since some contracts with commercials are ending, so there is a possibility to impose more strict sustainability rules
- RP19 is the location of the supply operations and the reuse area and therefore it is the main context for this project
- The big packaging waste streams are; cardboard, wooden single-use pallets, plastic foil, and milk cartons
- An unknown amount of packaging ends up in residual waste due to incorrect sorting of tenant workers and warehouse workers
- There are different kinds of return solutions in place at the return area in RP19, some of them are circular packaging solutions such as crates
- Due to poor signage in RP19 and a lack of attention to instructions and signs by warehouse personnel return items are not disposed of correctly
- Commercial units value ease of handling and accessibility to their products highly
- Commercial units are either part of a bigger operator or independent. Most of the personnel of units that are part of a bigger operator have never visited RP19 and are therefore unaware of the waste and reuse solution sorting process

Eco impact of packaging

This chapter covers packaging from an environmental perspective through literature and LCA analysis. This is done to get an overview of the impact packaging has and take more than just local impact into account.

Literature & desk research

Companies generally focus on packaging weight or packaging material to handle packaging when it comes to environmental issues, this can be considered a simplistic approach (Svanes et al., 2010). However, packaging inherits a great potential to lower the CO2 emissions in supply chains, making it an interesting carrier of sustainable development potentials (Nilsson et al., 2011). Moreover as "It is not products, but packed products that are handled in supply chains" the role of packaging as intermediate between products and good flows manifests even more potential for sustainable development (Nilsson et al., 2011).

An important factor to keep in mind is that the increasing length of global supply chains for products has led to a simultaneous increase in the use of packaging layers. Causing an increase in waste along the supply chain (Meherishi, 2019 #FIXME). Unsustainable packaging practices like these have become a threat to the sustainable development of a circular economy (Asim et al., 2022). In Norway this need for packaging layers is very apparent since it is a remote country where products have to be transported over big distances. This was also confirmed in a interview with supplier 2, see confidential Appendix A5. One of the types of packaging we come across in literature that poses a problem for the development of a circular economy is multi-layered packaging. The recycling of multi-layer packaging is a complex and multi-step process, as the materials are very closely laminated, it becomes extremely difficult to separate them from one another (Asim et al., 2022). This multi-layered packaging is used to package different foods and beverages at Oslo Airport.

Eco impact assessment of packaging types

To evaluate the eco impact of certain packaging choices during this project outcomes of existing LCA studies were used to make the impact measurable. The outcomes are given in CO2 impact per waste stream per year. The input is gathered from different past studies. The full calculations, assumptions, and more sources can be seen in Appendix E. Figure 37 shows the results.

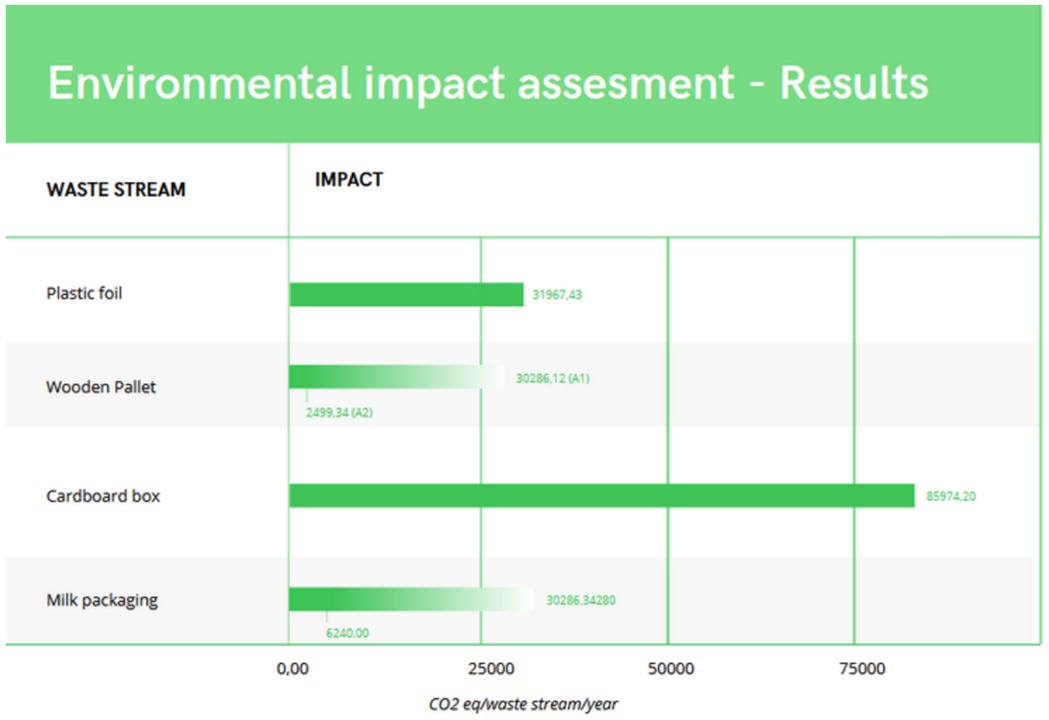


Figure 37: outcome LCA per waste stream, per year

Wooden pallets

For wooden and plastic pallets 2 sources were used. (Vásquez et al., 2022) (A1) and (Deviatkin & Horttanainen, 2020) (A2). These articles were chosen as they present a comparison of the pallet types that are also found at Oslo Airport. Both describe the difference in CO2 footprint for a wooden EPAL pallet vs a plastic reusable pallet, but with a different scope and functional unit. Study A1 was performed in Chili and does not take into account the number of trips, but takes the Co2 footprint from cradle to grave. A2 takes into account a number of trips and the study was done in Finland. The number of trips makes a significant difference since the weight of a plastic pallet is less heavy and therefore it also makes for less CO2 emissions during transport. In A2 the functional unit of 1000 consumer trips with a service life of 20 trips for a wooden pallet and 66 for a plastic pallet were used. For the end of life the wooden pallets are chipped and taken to incineration plants (information supplied by STENA recycling, the waste handler of Oslo Airport), therefore the incineration scenario was chosen. To crosscheck these articles on accuracy, another article by Deviatkin et al., (2019) was used which presents a review of various LCA studies on wooden and plastic pallets with ranges. All values used are found to be inside these ranges if we assume the plastic pallets are not made from waste plastic.

For the wooden pallets, it is assumed that the waste stream is entirely made from single-use pallets only and not from broken EPAL pallets. Since EPAL pallets are supposed to be repaired and reused. If we assume the wooden single-use pallets have relatively the same CO2 footprint in production as the EPAL pallets, the actual CO2 footprint (not taking into account the number of trips) will be closer to the number of article A1. Making for a yearly output of 30286,12 kg CO2.

Milk packaging

To analyze the impact of milk packaging research was done into the suppliers of supplier 3. The packaging suppliers of supplier 3 were found to be Elopak and Tetra pak. One LCA was found for

Elopak beverage cartons in North America (Elopak, 2021). However, this study showed massive differences from a study of Tetra Pak on beverage cartons, where the CO2 emissions were also shown per country, with specific information for Norway being available and the packaging being similar to the cartons used at the airport (Institut fur energie und umweltforschung Heidelberg, 2021). Therefore the data of Tetra Pak was used in this analysis. For more accurate data it is suggested to contact Elopak and gather this information, this was attempted via email during this project but Elopak did not respond. Supplier 3 uses 2 types of beverage cartons. Figure #FIXME shows the standard Milk carton, which was used the most at the Airport. Figure #FIXME shows their plant-based milk carton line, which does not use the plastic cap at the top of the milk carton. However this type of milk carton was only spotted twice during the visit to Oslo, so it is not taken into account for this analysis. The emissions from the production of the milk are taken out of the equation and this is only the emissions for the packaging. There is no accurate info on the exact percentage of plant-based material used in the packaging seen in Figure 38. Therefore for the analysis, the CO2 footprint of a standard beverage carton is used.

Outcomes

The outcomes can be seen in Figure 37. From the calculations, we see that the corrugated cardboard boxes have the biggest CO2 footprint. This is 85974,20 kg CO2 per year. It is unknown what the exact amount of plant-based material is in the milk packaging. The exact result can range from 6240 kg CO2 to 34380 kg CO2 per year. Plastic foil has a CO2 footprint close to the beverage cartons of 31967 kg CO2 per year.

Figure 38: milk packging at Oslo Airport

Expert interviews - sustainable choices

Multiple insights were gathered from interviews with the KIDV, suppliers of Oslo Airport, and F&B operators of Oslo Airport regarding sustainable packaging and decision-making on packaging. The full interviews and insights linked to this chapter can be found in Appendix A. The main insights are summarized here.

Firstly there are already quite some circular solutions that can be used in the B2B supply chain available. However, they are often not cost-efficient or unfavorable over single-use packaging when looking at CO2 footprint from cradle to grave. This can be due to an increase in weight, leading to higher CO2 emissions in transport or decreased ease of handling.

This means that Avinor could look into applying some of these innovations to their operations, as their main goal is a decrease in waste volumes. However, they have to weigh out the negative extra impact of the solution on the wellbeing of the plant to the decrease of packaging waste.

Other insights were that it can be useful to challenge the suppliers to make use of less packaging material. For instance, the use of packaging foil could be decreased, by asking warehouse workers to wrap it around the pallet in smaller quantities. It is often done in a certain way because that is how it has always been done, however, it is possible to influence workers/suppliers to make more sustainable choices by simply challenging them to do so. This was also seen during the second visit to Oslo Airport, where it became apparent that rocket salad used to be supplied in reusable crates, but supplier 2 had decided to switch that out for cardboard. Thereafter the F&B operator 1 central kitchen employees had asked for the crates back since that was their preferred packaging and supplier 2 had made this happen.

Furthermore, an interview with a representative of the supplier 2 group revealed that the CO2 footprint for their delivery is already being taken into account. They use a LCA software for CO2 calculations in their packaging decisions to come to the most environmentally friendly packaging solutions. Efficiency is also of great importance. For instance, unpacking products into circular solutions, to decrease waste at Oslo Airport would increase the work they need to do, which is costly and therefore not something they are willing to do. Moreover, a barrier to packaging in larger quantities is the fact that the supplier 2 group supplies to multiple smaller parties as well, who need smaller quantities. supplier 2 wants to limit their amount of product numbers to make the production more efficient. Therefore products such as rocket salad are packaged in convenience store-size packaging. This is not beneficial for Oslo airport, but it is beneficial for supplier 2, making this a conflict of interest.

The reusable crates from supplier 2 are part of IFCO. IFCO is an EU-wide system for reusable crates (IFCO, 2024), the way it works can be seen in Figure 39. Some products supplier 2 receives from their farmers come to their warehouse in the IFCO crates. If this is the case the products are put through again in the IFCO crates and that is how they end up at Oslo Airport. However, because the crates weigh more and have a set size, this makes it logistically impossible to see them as the better alternative in cases were products are sourced less locally. Therefore they also often use corrugated cardboard to transport their products.

Supplier 2 mentioned that they often chose multi-layered packaging, which was found to be a burden on the planet in literature, for certain products such as vegetables, as it keeps produce fresh for longer. For some products, there are no alternatives that make the products last long enough.

Shelf life is a typical challenge in the Norwegian context. Norway is a big country and it is far from where products are sourced. This means suppliers need to ensure an extra-long shelf life for products compared to other EU countries. The example was made by the environmental representative of Supplier 2 that in the Netherlands, where products arrive in less time, compared to Norway, less unsustainable packaging practices are needed. The quality of their products is one of the top priorities for suppliers.

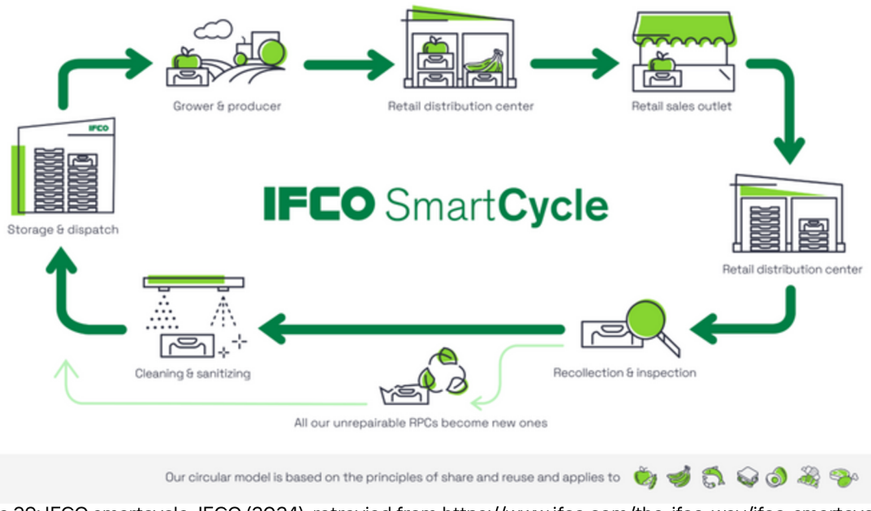


Figure 39: IFCO smartcycle, IFCO (2024), retrevied from https://www.ifco.com/the-ifco-way/ifco-smartcycle/

Key Insights - eco impact of packaging

- Multi-layered packaging is a threat to the circular economy but is oftentimes needed due to Norway being difficult to access
- Cardboard boxes currently have the biggest CO2 impact out of the measured packaging waste streams per year at Oslo Airport
- Reusable solutions do not mean better for the environment in every case, since they can cause an increase in weight, making the CO2 footprint from cradle to grave larger
- Challenging your suppliers can be a useful first step in decreasing packaging waste
- Supplier 2 takes CO2 footprint into account for all their deliveries/ products and decides on their type of packaging according to the outcome
- Supplier 2 has different priorities than Avinor concerning packaging sizes of products
- Suppliers 1 and 2, and Shop 1 often forward products in the packaging the products arrive in at their warehouse if the same amounts are ordered by tenants at Oslo Airport. However, if different amounts are needed, thus the delivery has to be assembled, a circular alternative, like reusable crates, is used.

The discovery phase - Conclusions

This chapter concludes the discovery phase of this project and takes insights from all three parts to define the problem areas and discuss in what way and to what extent they can be influenced. Furthermore, it sets the design direction for the concept that is to be tested at the airport.

It became apparent during the discovery phase that every stakeholder has their sustainability agenda. However, the barriers to adopting circular solutions differ for every stakeholder. Working together and personalizing supply operations for large clients such as Oslo Airport is an opportunity to go towards less packaging waste.

At Oslo Airport, the main problem for Avinor concerning packaging waste lies in the large amounts of packaging waste in volumes. However, we have to keep in mind that decreasing packaging waste at Oslo airport by introducing more reusable packaging solutions could also mean an increase in the CO2 footprint for certain products from cradle to grave. It is therefore not recommended to apply reusable packaging for all deliveries, as the environmental evaluation shows that this currently increases the CO2 footprint. Hence the remaining question is; is there something that would not increase CO2 footprint, but result in less packaging waste?

From the research, we can device certain problem areas in the context of Oslo Airport, which can be seen in Figure 40. Improvement in all these areas could lead to a decrease in packaging waste. However, the problem is that it is easier to have an influence in certain areas than in others, due to complex supply chains and limited communication. Therefore an influence mapping was made, see Figure 41 and Appendix F.

To influence these problem areas, it is important to have direct and good contact with their tenant providers, it is assumed that this is established and that communication forms a basis of trust. From the co-creation and interviews, it was shown that Avinor and their providers have the same ideals and goals and are in contact. Therefore it is possible to work together and demand that suppliers make certain environmental changes.

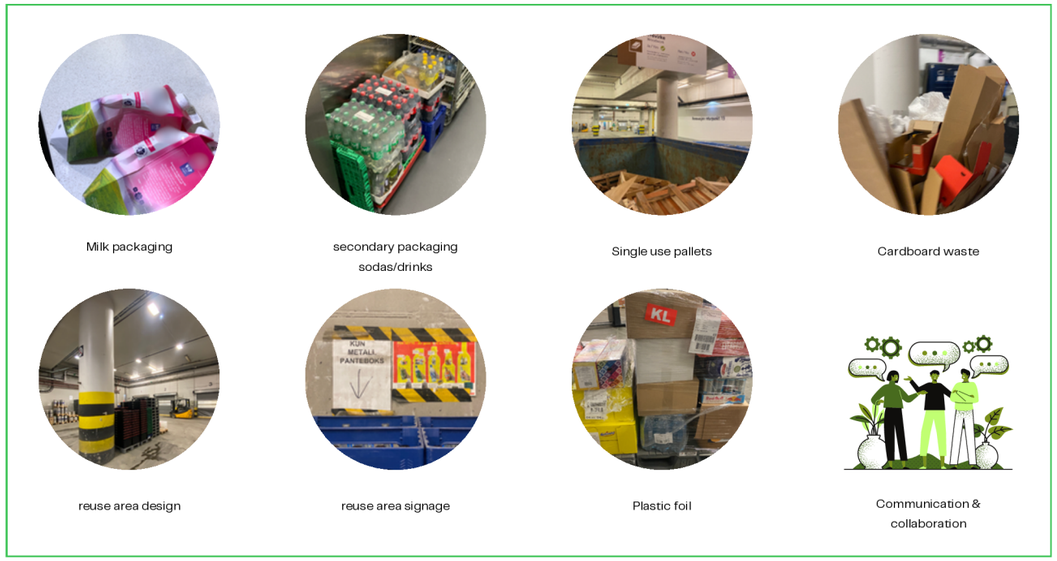


Figure 40: identified areas for improvement

Figure 41: layers of influence

The influence model

In the first layer, we see the redesign of the return space and signs. Since the easier that reusable items can be returned, the easier a reusability circle can be maintained (Gruenewald et al., 2023) improving the signage and layout is of importance. This is something that can be done without the complexity of the supply chain playing a role and without a big impact on the operations of other stakeholders. The impact of the redesign is more local. Another aspect Avinor can also immediately impact the communication between them and stakeholders, by getting into contact and providing training to warehouse personnel.

In between the first and second layers, we see the milk cartons. These can only be adapted in collaboration with supplier 3, but it might make operations different for both parties. However, as an interview done later in the project revealed, supplier 3 is Norwegian and open to collaboration, therefore this is something that is within reach.

Thereafter comes the plastic packaging foil and secondary packaging surrounding beverages. It would be needed to find a solution together with the brand and supplier to tackle these in such a way that operations flow as efficiently, but more circular, while remaining of the same quality. This requires supply chain alterations from both sides and possibly also a redesign of the whole product, making it essential to collaborate with the whole supply chain, from brand to supplier.

Lastly, the pallet and cardboard waste. These are forms of transport packaging that are used from the very source of the product for protection and transport and often, this packaging is not taken off until it reaches the end destination. There is an ecosystem in place. Tackling this would require the most adaption for the whole supply chain and might not always result in a smaller eco-footprint. Furthermore, the supply chains are often not as transparent and might even come from outside of the EU where less strict regulations are in place regarding packaging. Resulting in issues when trying to get into contact with stakeholders and a high chance of encountering different priorities for these suppliers compared to the local Norwegian ones. Tackling this problem could require a change in the source of the product and a potential approach would be to focus on more local sourcing.

To make an impact on a large scale and go toward a circular airport the way products are imported and sourced needs to be altered. Finding and implementing the solution to decrease packaging waste is complex and it would be overly optimistic to assume that meaningful progress can be made in less than a year. For this reason, it is important to look at the bigger picture with a future-focused approach. Therefore a roadmap with a vision for Oslo Airport, alongside the concept is the chosen approach to enable this within the frame of this graduation project. The roadmap will feature different solutions and developments/trends to implement and keep an eye on, that could eliminate packaging waste. Keeping employees and suppliers in the loop on these developments means Oslo Airport can become a frontrunner in the area of packaging sustainability.

Focus Area

To decide the area to lay the focus on for the design concept the different areas were scored in a weighted objectives method, see The criteria were the following;

- feasibility in the short term (<1 year)
- estimated eco benefit, from a scale from 1 to 5, with 5 being very feasible/very beneficial.

The results can be seen in Table 5. For some areas, assumptions had to be made. The eco benefit of reuse area/signage redesign was one for which no data is available. Therefore it is assumed that the initial impact is low, as the main problem based on observations and interviews is wrong sorting. For example, the supplier 3 milk carriers end up in waste streams. This is the main contributor to eco-impact, but it is not significant in the amount of waste compared to the tonnes of cardboard and wood that are thrown away yearly. However, In the future, more reusable packaging solutions are expected and will replace single-use items. Therefore there will be a need for more storage space and clear signage. The impact of redesigning the reuse area is therefore assumed to be significant in the future, as the need will be high and it contributes to a decrease in eco-impact in other areas.

The decision was made to focus on redesigning the reuse area for the concept. This is one of the areas that needs to improve to optimize packaging sustainability and part of moving towards a circular future. To holistically tackle the problem of packaging waste in the long term, the second deliverable of this graduation project is a roadmap. This roadmap, presenting interventions for all different problem areas, was also developed over the course of this project and will also be presented in the next chapters.

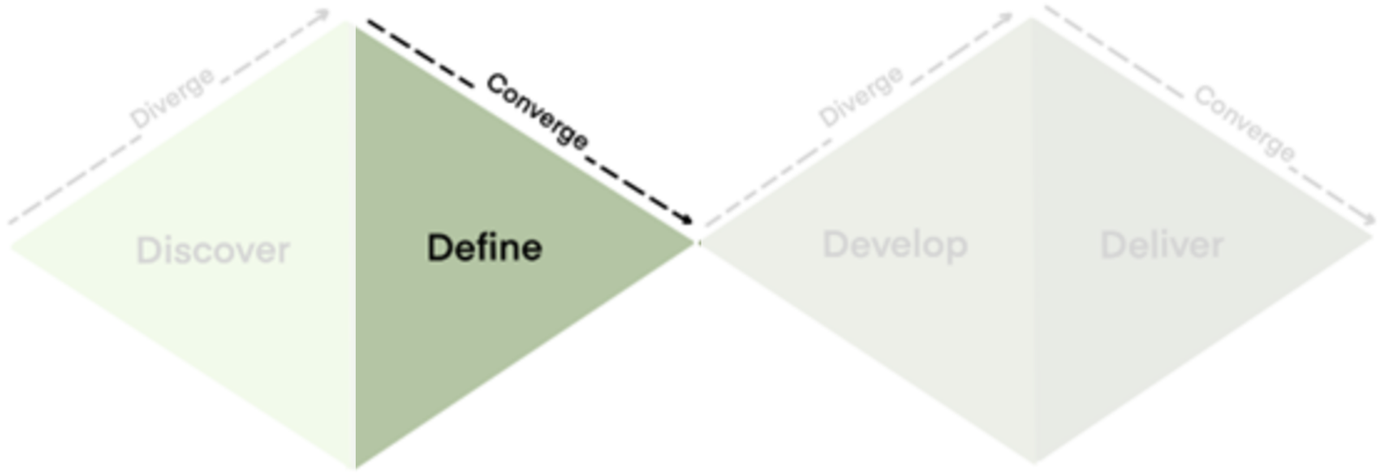
Next to this focus, the milk carton concept was another area of interest for Avinor. However, due to time constraints and the unavailability of supplier 3 stakeholders, this was not feasible to develop into a final concept within the time frame of this project.

	Feasibility	Eco benefit	Additional comments	result
Milk packaging	3	4		**7**
Secondary packaging of sodas & drinks	2	3		**5**
Single use pallets	1	4		**5**
Cardboard waste	1	5		**6**
Reuse area design	5	2		**7**
Reuse area signage	5	2		**7**
Plastic foil	2	3		**5**
Communication & collaboration	4	3	Avinor: We are working on this, so preferably not the area of focus.	**7**

Table 5: weighted objectives table

Phase 2

D E F I N E



Design goal and Roadmap goals

In this chapter, the goal for the concept is defined and the future vision for the Roadmap is established.

Desing Goal

To define a design goal for the warehouse redesign the current problems that arose from observations were reviewed, a visual interpretation of this can be seen in Figure 42. To define a design goal there are multiple questions that can be used as a guide:

- Who is the target group?
  - Workers who visit RP19 to return packaging solutions that are to be picked up
- What is the goal?
  - Make it clear where circular packaging solutions have to be stored for return pick-up
  - Create more trust in where packaging solutions are and to which supplier they belong
  - Create more space for future circular solutions that might be introduced

With these in mind, a design goal for the redesign of the reuse space was set.

Design goal:

"I want to design a new solution for RP19 that;
- enables workers who are returning packaging solutions to easily detect the designated areas for these items
- enhances trust in the circular packaging economy
- increases capacity for future circular solutions"

Figure 42: First overview of warehouse insights

Roadmap future vision

For the roadmap, a future vision that needs to be achieved to go towards less packaging waste at Oslo Airport was defined. The future vision is;

*The circular airport of the future, characterized by transparency, powered by **locality**.*

Enabling employees and travelers to make the most environmentally friendly choices in the most accessible way

The future vision is inspired by the challenges and opportunities identified in the discovery phase. It was seen that extruding influence in packaging decision-making is hard, but that communication is seen as an enabler.

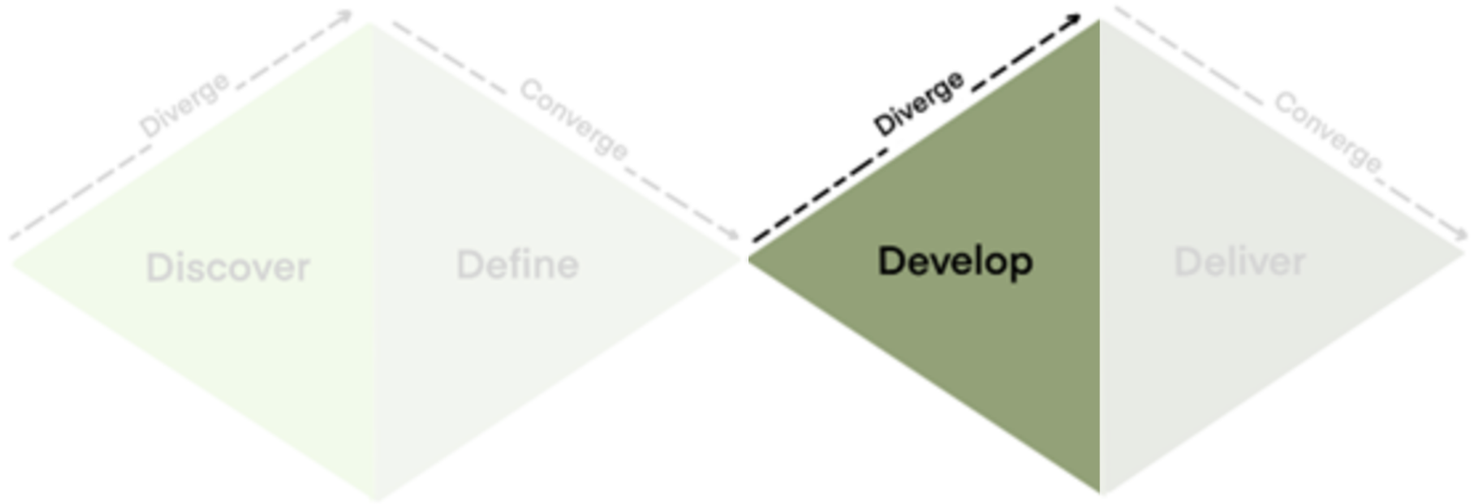
Moreover, by communicating transparently with each other and the travelers at the airport, the importance and improvement of searching for more circular and sustainable alternatives can be highlighted. Furthermore, doing this can inspire suppliers and travelers to make the most environmentally friendly choices by showcasing the good that is being done. This cooperation can even result in the most environmental and economic outcomes for all of us (Flygansvær et al., 2018).

The second part of the future vision, about enabling employees and travelers to make the most environmentally friendly choices, is inspired by the contracts that are currently in place at the airport. Doing this is already part of the recommendations stated in this contract and tenants get “plus” points if this is done.

This future vision was evaluated by the Avinor and got approved.

Phase 3

D E V E L O P



Concept development

In this part of the report, the concept is developed. It starts by stating relevant literature. Thereafter it describes the idea generation and evaluation phase. The evaluation is done through testing, with relevant stakeholders at Oslo Airport and with participants at the TU Delft.

Background research

Reuse area signage

The discovery phase has shown that an important missing element in the reuse area is signage. There is an absence of clear signs showing the sorting of the reusable packaging. Further, there is no signage seen on the ground and walls, except for improvised cardboard/paper posters. This leads to unclear guidelines and wrong sorting, through which reuse solutions end up in the waste bins. To improve this, signage has to be created. Signs have to be universal, so they are understandable for everyone in the warehouse, and through literature guidelines were established for the design of such. A paper by Rodrigues et al. (2018) examines the signage at different hospitals, even though this is a different setting, we can use these basic rules for signage, as they have the same purpose of wayfinding. Some guidelines derived from this paper are:

Viewing Distance (m)	Minimum Caps Height (mm)
0.25	1.25
0.5	2.5
1	5
2	10
3	15
5	20
10	50
15	75
30	150

Table 6: font size and viewing distance, derived from https://www.signsontime.com.au/articles/design-considerations-for-your-signage-and-audience

- Use upper caps wording only to emphasize certain elements, but other methods, such as bold lettering, are preferred
- Use bold lettering for primary information, to improve legibility
- Use minimum font size, that can be derived from tables, such as seen in Table 6, to make sure that the text is legible
- When using symbols it is important to test them among the target group
- Symbols are useful to make it easier to see from greater distances
- Symbols are not intended to replace text, but they should integrate and have a clear relationship
- Some colors have established meanings that should be considered
- Signs should be well-lit
- All signs should be related to a common design theme, which means that **signs should be consistent and standardized throughout the whole building**. If possible, the design should meet the image of the institution

So for the redesign of the signage, it has to be kept in mind that there are already signs in place for waste disposal. Therefore the signs designed for the reuse space should mirror these images, as it creates coherence and clarity.

Moreover, signs containing either icons or pictures of permitted items improved sorting performance and consistent positioning of the signs improved sorting performance compared to random positions for both pictures and icons. On top of that, presenting both permitted and prohibited items can interfere with performance (Wu et al., 2018). Therefore **the new signs should not display prohibited items and use pictures or icons with consistent positioning**.

In the recycling process information on packaging can ease the process of identifying its material type etc. Furthermore, the packaging also has the role of providing the end-user with information such as information to consumers on origin, content, etc. to make the consumer buy the right products and not bring products home that need to be thrown away (Nilsson et al., 2011). There was no information available on return items and information on the packaging, but taking learnings from this literature, it is an interesting concept that could be worth applying.

By working on providing information to tenant and warehouse workers, providing information on the packaging might lead to less incorrect sorting and thus less unnecessary packaging waste.

Digital tags

There are future developments that could help in overcoming barriers related to adopting a more circular approach in packaging used along the value chain. Digital paF&B operator 1orts and mandatory reporting could provide a way to audit and incentivize the reuse of packaging, allowing governments to focus on prevention and framing packaging as an asset, rather than inevitably turning into waste after a short single-use cycle. Digital paF&B operator 1orts could even address business concerns (or excuses) for not investing in reusable packaging (Ellsworth-Krebs et al., 2022). Furthermore, it is the first step in enabling a wide range of stakeholders to work together and create systems for reusable packaging, as the coordination of material and information flows is crucial (Ellsworth-Krebs et al., 2022).

Currently one of the problems for the adoption of circular packaging is a lack of trust. Packaging is not systematically tracked (e.g., a retailer cannot determine where an item was lost or damaged and who is responsible) as it moves between manufacturers, retailers, customers, or regulators. Moreover, there is a lack of data about how many times it can be reused before being worn out (Ellsworth-Krebs et al., 2022). Therefore digital paF&B operator 1orts could also have the potential to address questions about financial viability (Ellsworth-Krebs et al., 2022). Currently, trials are running in this area but they are mainly focused on the food and beverage sector

(Ellsworth-Krebs et al., 2022).

Traceability also leads to reducing the contamination risk of food and beverage items in reusable packaging, leading to a lower chance of cross-contamination for people with severe allergies (Ellsworth-Krebs et al., 2022).

Warehouse Layout

To get an idea of how to make the area for the return of the reuse items more efficient it is important to dive into information about designing an efficient layout for a warehouse.

First off, there is a difference between static and dynamic storage. In the case of reusable packaging, we can differentiate between packaging that gets picked up more frequently, eg. every day or once every two days, and packaging that is stored for a longer time (REB, 2024). Different types of layout options use this to divide the space into different areas, the most well-known ones to consider are U-shaped, I-shaped, and L-shaped patterns, see Figure 43 (REB, 2024).

Multiple different principles have to be taken into account when designing a warehouse and they can be summarized in F.A.C.T., flow, accessibility, capacity, and traceability (REB, 2024). These lead to different requirements of the redesign.

Flow: There needs to be a good flow in the warehouse and it is important to study the packaging supply flow and return process. **The concept has to clarify this flow via signage**.

Accessibility: **All products need to be accessible and visible**. It is important to have **at least 4 meters of aisle space** in between racks to be able to pick up products.

Capacity: **Only about 85% of capacity has to be used and the rest has to be "extra**"

Traceability: **Via signs, it should be easy to track where reuse items have to be stacked**, and through digital tags and barcodes it should be known how many reusable items are stored at RP19.

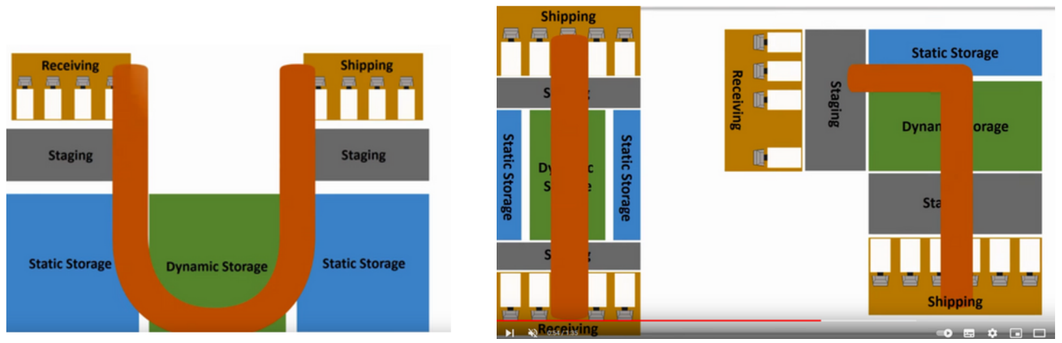


Figure 43: different established warehouse layouts retreived from https://rebstorage.com/videos/warehouse-layout-product-flow-options/

Requirements for the RP19 concept

From the previous visits, interviews and reserach different requirements for the concept were set.

	Requirements concept
1	New signs should: • not display prohibited items • be consistent with existing signage • be legible • be validated through testing (after first development)
2	The concept enables workers who are returning packaging solutions to easily detect the designated areas for these items upon entering the warehouse
3	The concept increases capacity for future circular solutions by 15%, so that the current solutions take up 85% of capacity
4	All return items need to be visible and accessible in the new concept
5	The concept should leave enough aisle space for operations
6	The concept should not increase the time the warehouse workers need to return their items and throw away their waste
7	The concept needs to be safe

Inspiration gathering

To start developing and to get inspired, visual images of other warehouses and innovations were looked up and made into a collage, which can be seen in Figure 44.

Brainstorming

Through brainstorming and How to's the first initial ideas for the concept were made, this can be seen in Figure 45.

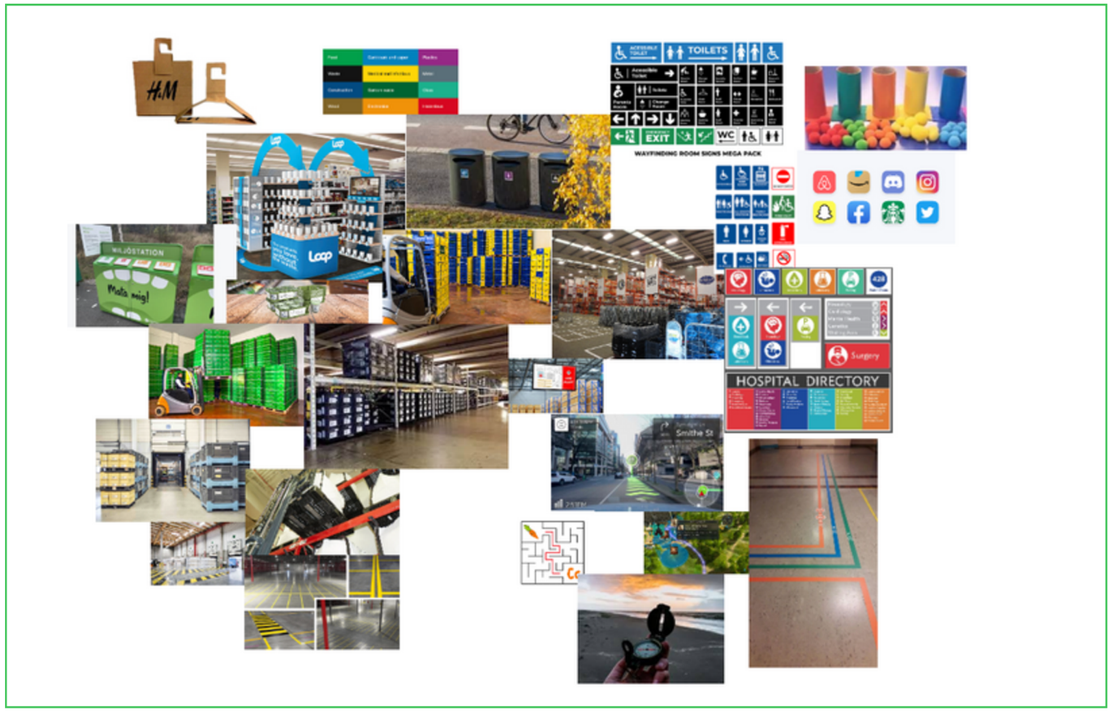


Figure 44: inspiration areas

Figure 45: H2 and initial brainstorm

I concluded this phase with concepts to integrate with the redesign of the warehouse, which can be seen in Figure 46.

Figure 46: concepts to integrate

Research at RP19

To restructure the reuse space, more research at RP19 had to be done. One of the things to do was to measure the space to know the dimensions. This was done with a laser distance meter. Furthermore, from past visits, it was seen that not all return orders were picked up as frequently. As past research showed that effective warehouse layouts are based on more frequently flowing goods and more static goods being divided into different zones (REB, 2024), this could be interesting to uncover per return order. With the help of security company , the return orders based on the frequency of pickup were mapped to guide the design process, see Figure 47.

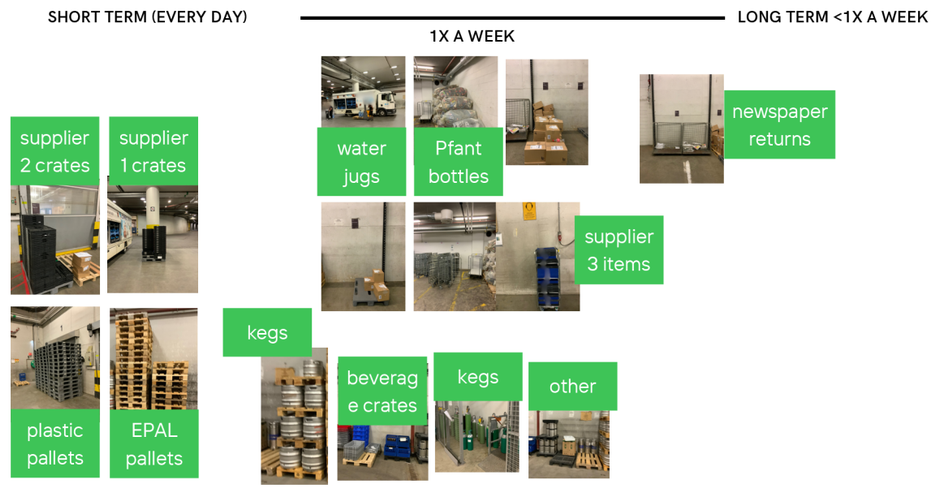


Figure 47: returns sorted according to pick up frequency

Intial exporation

During the second visit to Oslo, try-out visualizations were made of signs for Rp19 to test the attitude of warehouse and security company employees toward a redesign of the signage in the reuse area of RP19. This was done as they are important stakeholders in the design process, the try-out visualizations can be seen in Figure 48.

The color pink was chosen to represent reusable packaging as this color is not used to indicate a waste stream available in Rp19 yet. Therefore this could be a good color to indicate reuse solutions and set them apart from waste streams. The try out visualizations were also rendered to give an impression of what they might look like when they are installed in the waste station.

3 people were approached to gather initial feedback during the second visit. 1 security company worker and 2 warehouse workers. The interactions took 5 minutes per person. In 2 of the 3 interactions, the preference went to the signs that showed the stacking of the reuse solution.

Additional comments from this small exploration were that supplier 2 counts its crates and documents how many are returned, and it was mentioned this could be done more efficiently and takes time. One of the wishes for the concept is therefore added, that it could aid this process of counting crates.

Furthermore, return items are now sorted according to the supplier, but this makes it harder for employees because they all go to different areas. As an example; F&B operator 1 and Store 1 both have kegs that have to be returned, but they are stored in different areas. One warehouse worker mentioned that maybe there is a way they could both go to the same area, but it is clear for the people who pick up the products to which supplier they have to be returned.

It was also mentioned twice that the space is not used optimally in their opinion.

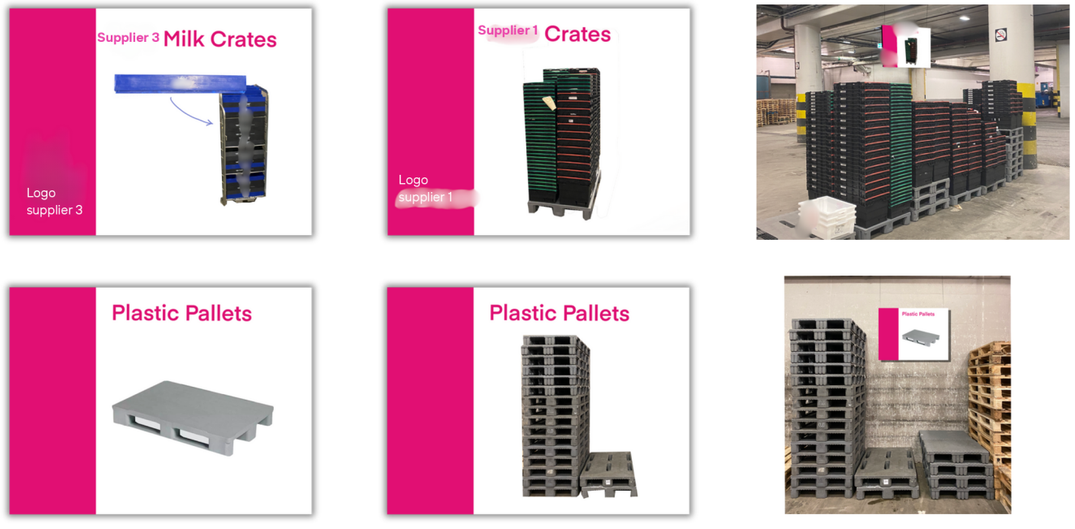


Figure 48: returns sorted according to pick up frequency

Key Insights - Intial exploration

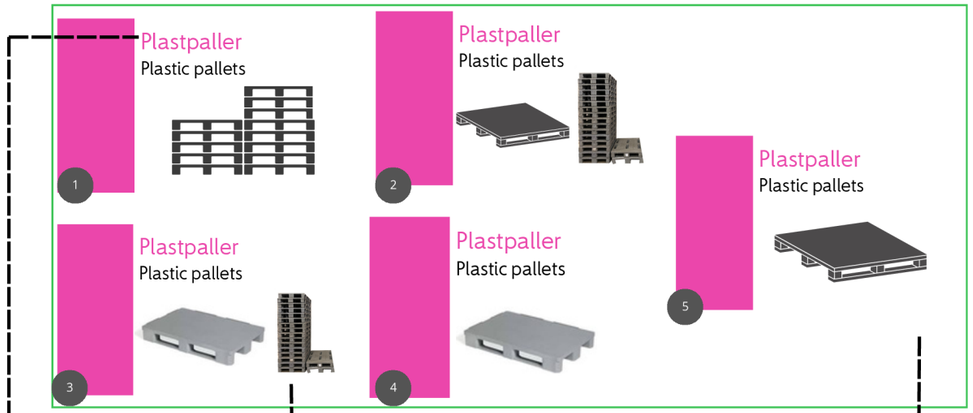
- Signs should show stacked items
- The same type of return items are sorted in different areas due to different suppliers
- The current layout and storage does not make use of the height of the space

Conceptualization

Signage

For the third visit the concept was developed and the signs and layout were made. The signs can be seen in Figure 49 and are similar to the tryout signs. The choice for certain elements and why certain design decisions were made can be seen in Figure 50.

Figure 49: Singage concept 2



In the new signs, the Avinor font is used, this is done to comply with company design rules.

The signs use icons, pictures, and stacking pictures. From the literature, it was found that icons/pictograms can be useful in conveying information, but that the signs have to be tested to evaluate them in their context (Rodrigues et al., 2018).

The mockups show different alternatives. One option using an icon, another using cut out realistic photographs and alternatives for showing stacked or unstacked objects, this is because this choice could not be made from literature and there was a need for this to be evaluted on site though testing.

Existing signs as guidelines, and to keep one coherent style across the whole warehouse. As shown by literature this is an important element. These signs however also show what should not go in the bin, this was left out in the signs for the return items, as presenting both permitted and prohibited items can interfere with performance when the signs are icons (Wu et al., 2018).

Figure 50: Elements of signs

Lay out

Another element of the concept is the layout of the space. Through the research and brainstorming a first layout concept was developed.

The concept combines different methods to improve wayfinding. It uses lines on the ground, to improve the flow. The proposed new route is presented in Figure 51. The colour green is chosen to represent waste disposal, as the waste disposal area is currently also painted in the color green. The color pink is chosen for the reuse route because the signage will be in this color as well. Moreover, it is suggested to sort according to reuse item type, as this was an insight from the first testing of signs and delivery frequency. The new layout with locations of return items can be seen in Figure 52. The route provides the shortest route can be taken to the waste separation area

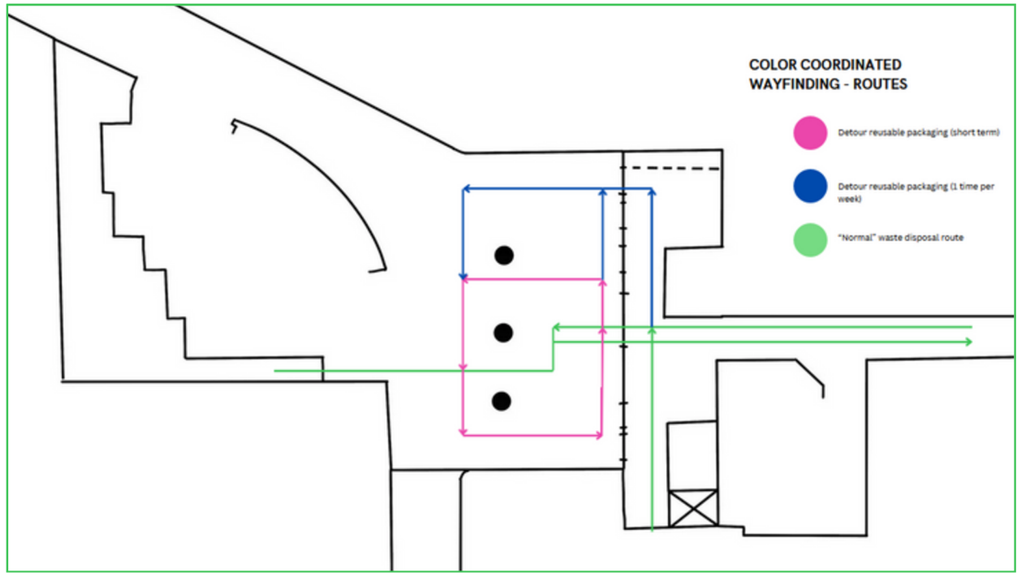


Figure 51: proposed route

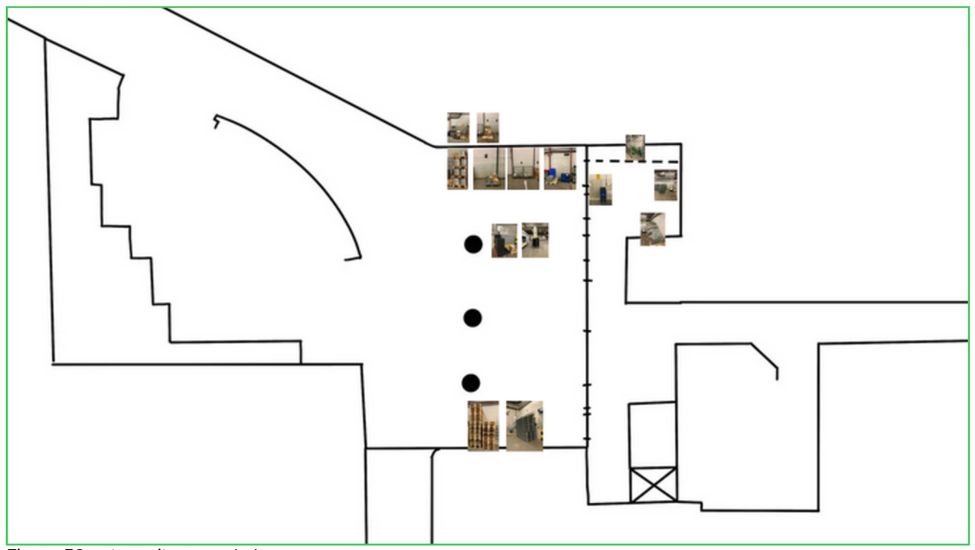


Figure 52: returns items and places

since time is of the essence for the warehouse worker. The routes eliminate two-way traffic and make waste separation more efficient.

In the new layout, the pallets are stored on the south wall. These pallets are frequently taken back and currently, the different pallets are scattered over the area. This should create unity and clarity for warehouse workers and suppliers.

The items in the upper right area are gas cylinders (since they need to be kept behind fences to keep them from falling making it not possible to move them to another location) plastic bottles, and supplier 3 return items. The plastic bottles use the wall to not fall over and are already efficiently stacked, so there was no immediate need to move them. The one big difference is that in this redesign the supplier 3 return items are at the same place, instead of them being apart from each other. This should make it easier to indicate where workers have to return supplier 3 return items and eliminate the wrong sorting of the plastic milk carrier crates.

The area next to the upper pole (indicated with a circle) is used for supplier 1 and supplier 2 crates. This area is easy to reach for suppliers. Since these are frequently picked up, easy access is of the essence. It is also not expected to overflow easily due to this frequent pickup and can stay as it is.

The rest of the return items are stored together on the north wall, where the pickup of return items is easy and it is not in the way of operations. Meaning it is okay if it is not taken back every day. This is also a possible area to store with the use of warehouse racks and forlifts to increase capacity .

An important factor in the concept is eliminating human sorting errors and creating immediate awareness of the new reuse routes. This is done by placing information, Figures 53 and 54, at the two entry points to RP19 that show where the different items are stored.

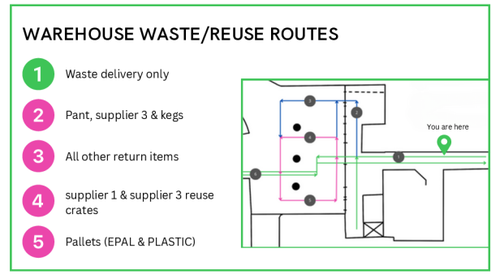


Figure 53: entry sign concept

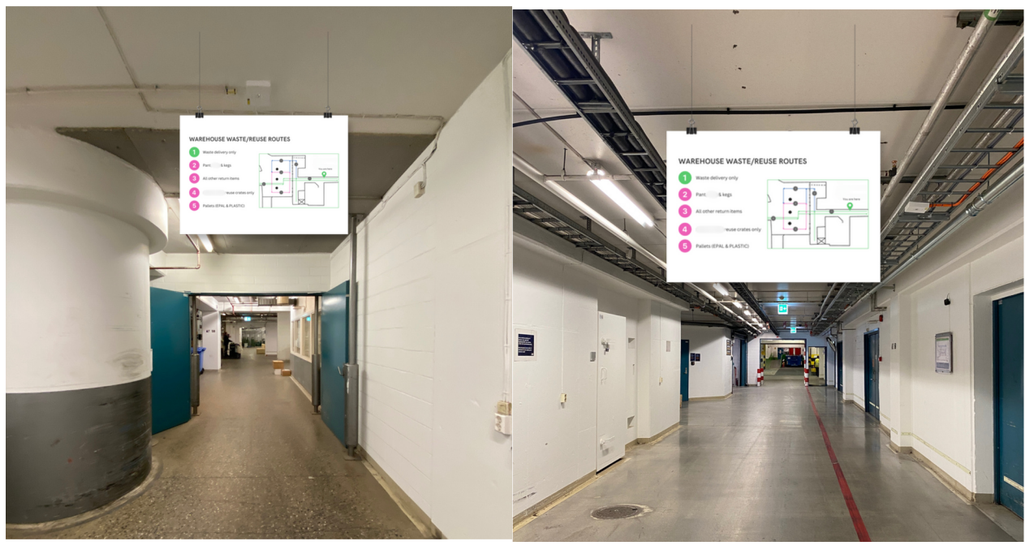


Figure 54: entry signs renders at entry points of RP19

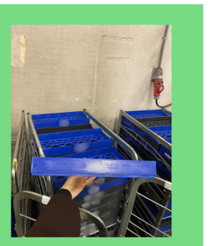
Storyboard concept

To better understand the flow for a warehouse worker a storyboard was made, which can be seen in Figure 55. The route he has taken is shown underneath the Figure.

1

Warehouse worker enters the waste station, where he reads the board with assigned routes is displayed

2

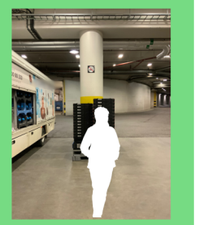


He has milk carrier rates with him, so he takes the detour reusable packaging for this and places his items in the carriers

3

Thereafter he places his weekly pickup packaging items at the north wall

4



Immidiatly after he also places the crates for supplier 1 and supplier 2 in the middle of RP19 for the daily pickup

5

He moves on to the waste containers by following the green route

6

Lastly he delivers the pallets that were on the bottom of his forklift at the south wall

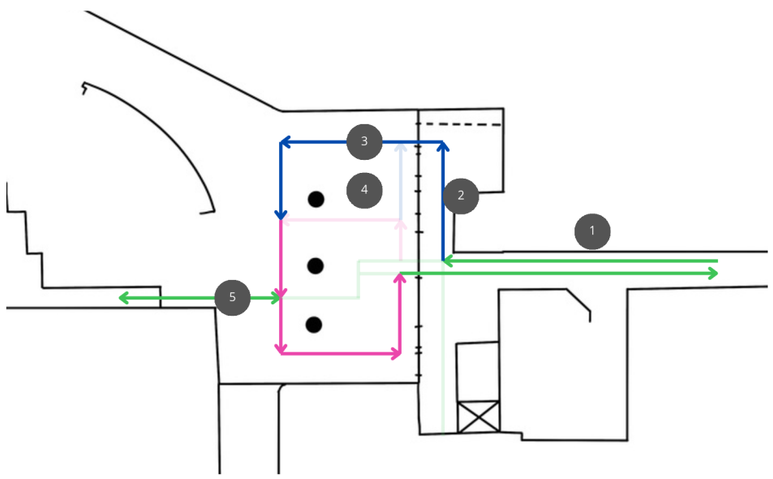


Figure 55: storyboard

Layout renders

Different renders of the layout of the reused space were also made, see Figure 56. During the testing at Oslo, the goal was to uncover the preference for colored signage or numbered signage. The question arose of whether this colored signage would not interfere with waste sorting color coding.

A way to use the height of the space is to use pallet racks and forklift trucks to stack items. I propose doing this on the north wall (area 3 in Figure 53) and for the crates in area 4. Since the space is high, these areas are the best places to do this. It was found that the height of the north wall is about 3,5 meters to the first obstruction.

Figure 56: renders ground signage at RP19

Blender Model

To accurately divide the space with dimensions and place items in the space a model of the space was made in a program called Blender. See Figure 58. This model was used to showcase where potential areas for pallet racks are and how the signs would be placed in the space.

Thereafter this model was transferred to Rhino and to add the floor signage, see Figure 59.

After this, it was possible to render the space in Twinmotion, add the signs, and make it look more realistic.

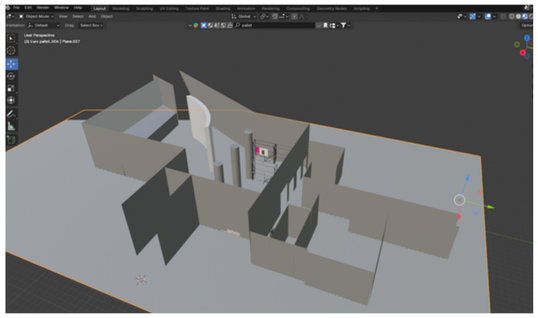


Figure 58: first blender mock-up

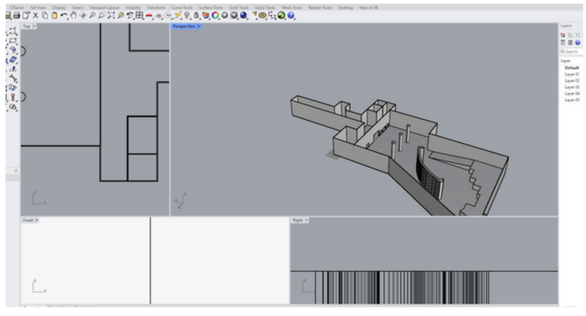


Figure 59: Rhino mock-up

Concept testing

This chapter presents the testing done to validate and iterate on the concept, the highlights of these tests are mentioned here.

The concept testing can be split up into signage boards and layout/flow of the space.

Signage

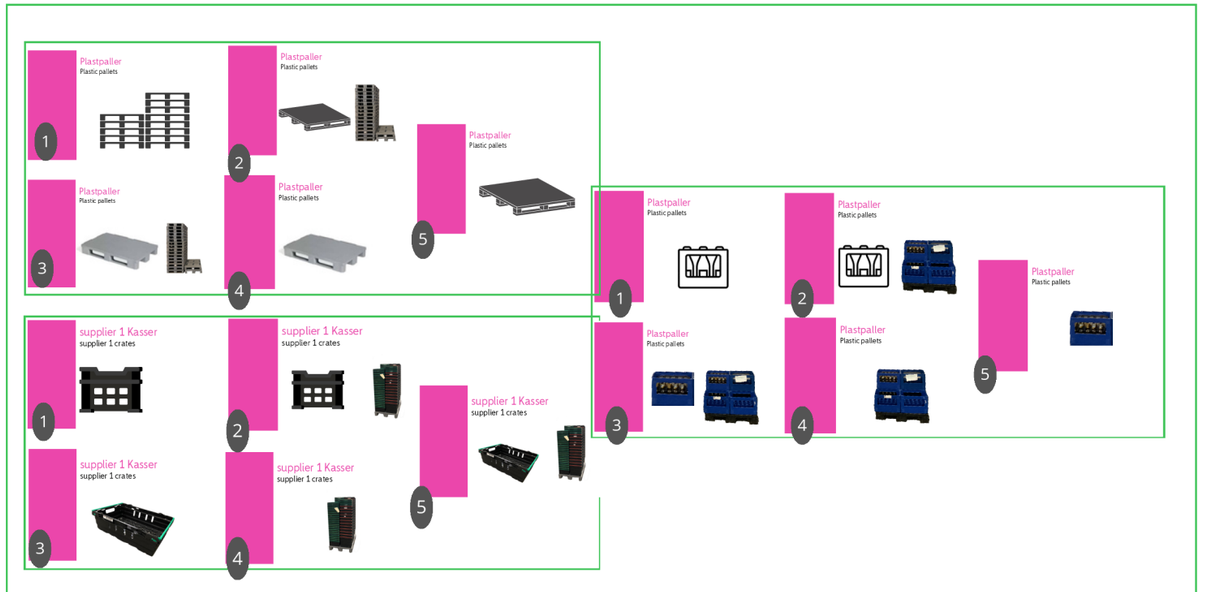
The developed signs were tested by presenting them to 6 warehouse workers, the testing plan can be seen in Appendix H. The outcomes can be seen in Figure 60.

It was mentioned that for the pallets it is important to see how high up they can be stacked to fit optimally in the trucks. Moreover, the supplier 1 crates have to be sorted by size and displayed with the different colors of the handles. Therefore it was mentioned that it needs to be clearly shown that they have to be separate.

There is not one type of sign that came out as best from the test. The motivations for choosing what sign was preferred were different. Some workers mentioned that it should be displayed how return items should be stacked, others mentioned that that is part of the onboarding and they preferred the most simplistic signs, due to it being able to recognize immediately. One universal thing was that the realistic cutout photos of the product were preferred over the icons, as they resembled the product most and were clear.

Layout and flow

Two in-depth interviews were done with an F&B operator 1 warehouse representative and security company worker to test the concept, which took 35 minutes. The plan and transcript can be found in Appendix A2 and H2.



Sign	1	2	3	4	5
Plastic pallet	2 votes	X	2 votes	2 votes	
supplier 1Crate	X	1 vote	3 votes	1 vote	1 vote
Beverage crate	X	X	3 votes	X	3 votes

Figure 60: outcome signage test

The signage in Figure 49 and the renders in Figure 56 were shown to 6 warehouse workers at the airport. The time these warehouse workers had was limited, therefore the conversations took approximately 5 minutes per warehouse worker.

Feedback F&B operator 1 warehouse representative

The feedback provided by the F&B operator 1 warehouse representative was very insightful. He mentioned that the reusable pallets are now divided in the space by the supplier because there are big deposits on them. The plastic pallets are tracked with barcodes, but the wooden pallets have to be counted and taken back per supplier manually. It sometimes happens that too many are taken back and this causes fraud in the system and great money losses. There is a lack of trust between the different suppliers. Therefore gathering them all in one place is tricky, if there is no way to monitor the pallets per supplier.

The same holds for the beer barrels, on which there is a deposit of around 30 Euros.

He also mentioned that some return items are becoming less relevant, such as the return of newspapers and magazines. As these become more scarce in the future it can mean that the space these take up now can be used for new return packaging that has to be stored in the future.

He thought the use of ground signage and routes was great. Especially the use of the signage at the entry points of the warehouse is useful. Making it as simple as possible is essential, both for the signs and markings in the warehouse as their time is limited.

If the system of routes and boards works well he thinks a big benefit would be the ability to follow up on wrongly sorted return orders and make it easier to discipline and follow up with fellow warehouse workers.

"If there are signs and routes I can just say to someone sorting things wrong, you can just follow the lines and boards, can you not read? Instead of understanding that it sometimes goes wrong and being able to do nothing about it"

He agreed with the color coding of green and pink since this fits with the paint in the warehouse and pink is not being used for a waste stream (in RP19) yet.

He had some more critique on the route and the warehouse racks. For the route, he mentioned that the flow should be different. A warehouse worker will always first do the waste disposal, and thereafter the return items. Therefore the first route that is followed is the green one. It is important to keep behind the trucks instead of having to pass them in the front.

For the warehouse racks, he mentioned that he was not a fan. Currently, the crates and pallets are stacked to a height that fits optimally in the trucks. Using warehouse racks would eliminate this option and result in having to re-sort them when they are picked up. The biggest concern was that currently, suppliers can get their items that they have to take back themselves. However, they do not have access to forklifts, meaning that when there are pallet racks, they would need help to get them down. This is not something they have time for.

For all the signage the message was to make it as simple as possible. He preferred to have one color for the return orders, as he does think the different colors could interfere with the color coding of waste sorting. Therefore he preferred the all pink and green render. Furthermore, he mentioned that marking areas that have to be kept free for the return items would be useful.

The security company employee also emphasized the need for clear and simple signage and mentioned the deposit systems that are in place for pallets but had no further feedback.

Short feedback from warehouse workers

The feedback given by 6 warehouse workers that I came across was consistent with the previously mentioned feedback. The routes have to be the shortest and most sensible and different colours could interfere with waste sorting. The most positive reactions were evoked by the renders of the information boards among entering the waste station as it was seen as a great improvement to have information of where things are located available. However, it was mentioned multiple times that ground signage would have to be tested for effectiveness, as they were uncertain that they would actually be followed. Feedback on warehouse racks was negative.

Fist iterations

Due to negative feedback, it was decided to eliminate the use of warehouse racks in the concept for the short-term future. Implementing this now would result in more difficult and time-consuming operations.

Moreover, a new version of the route was made, which can be seen in Figure 61. The route is changed to avoid having to go behind trucks, due to safety reasons, and the wayfinding should take into account that warehouse workers throw waste before visiting the reuse area.

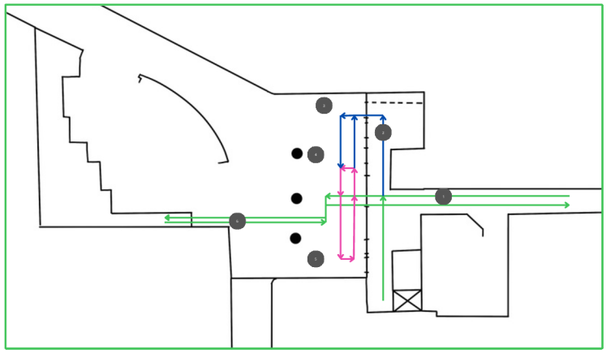


Figure 61 first iteration route

Key Insights - Concept testing

- For supplier 1 crates and beer barrels, it is important to show the difference between the different sizes of crates and how they should be stacked, for other return items a picture of a single object can be used, as this is easy to recognize and simple
- Some return items will disappear in the future, creating room for new ones
- Cut-out realistic pictures were preferred over icons
- Wooden pallets have large deposits on them, making it important to differentiate per supplier
- The pallets are stacked to a certain height to fit optimally in trucks
- Since suppliers do not have forklift trucks to take back return packaging, it is not beneficial for operations to make use of warehouse racks, as this creates more labor for warehouse workers
- Green and pink color coding makes sense
- The new concept is a way to discipline warehouse workers
- Warehouse workers will always first dispose of waste and thereafter return circular items

Roadmap development

This chapter elaborates on the development of the roadmap

The first step in creating a roadmap to zero packaging waste was to identify the key problem areas and set a future vision. This process is described in the previous chapters and the roadmap builds upon this by setting goals for each problem area. The goals set for 2050 were:

Milk packaging: No more milk cartons in waste, all deliveries are done using a circular alternative to the milk carton packaging
Single-use pallets: Zero single-use pallets
Cardboard: No more B2B packaging waste comes from cardboard. Cardboard packaging is replaced by a reusable alternative
Plastic foil: Zero plastic foil waste
Secondary packaging: Eliminate all waste from secondary packaging by integrating circular solutions to transport products
Reuse area signage & layout: Designated areas for return items are easily detacable leading to no waste due to incorrect sorting and the capacity for return items is enough to cover all incoming new circular solutions.
Communication: Clear communication between all stakeholders and regular meetings. There is collaboration along the supply chain to work on reducing packaging.

The different problem areas were researched to come up with different existing interventions and trends. Planet Reuse, which is a platform that gives an overview of many existing reuse/refill solutions from different companies was a big source in this information-gathering.

With an understanding of the context and initial ideas, the next phase of the road mapping development was entered which started with mapping sessions. In this, solutions were brainstormed, synergies between the different problem areas were identified, and the feasibility of the different interventions was assessed. In this, it was also taken into account that some interventions can be applied immediately and others later. A visual of this process can be seen in Figure 62, which shows the problem areas, the goal, the possible solutions, and the inspiration. These mapping sessions provided an overview of the elements of the roadmap.

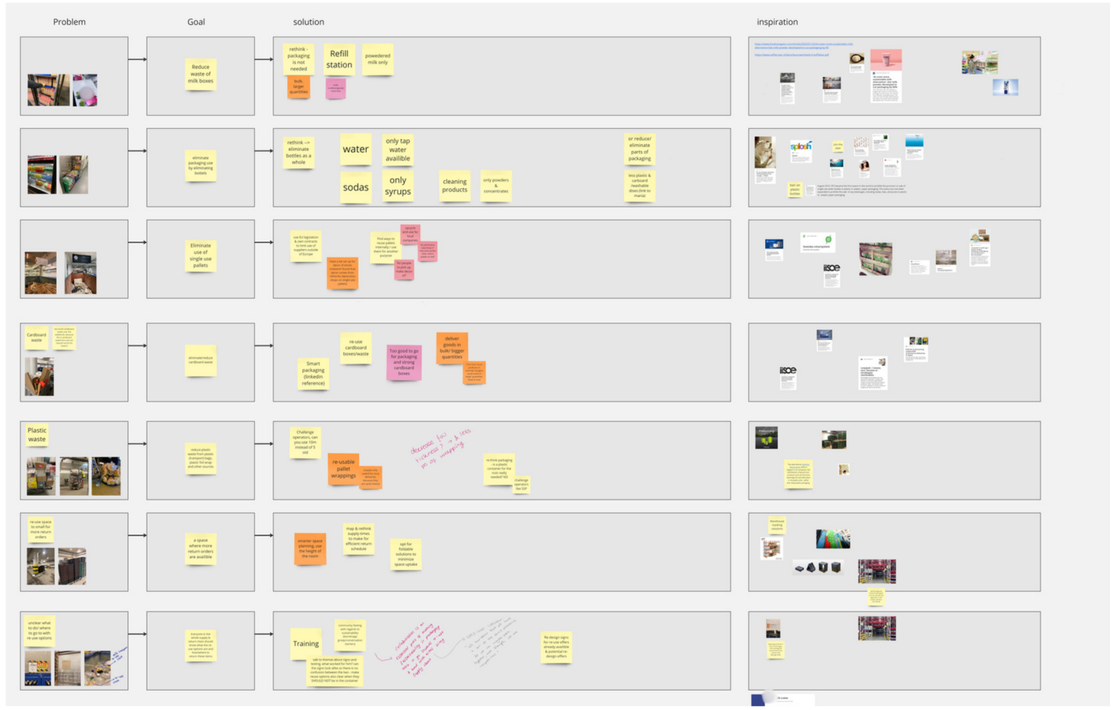


Figure 62: first iteration brainstorm and insipration roadmap

Interventions on the roadmap

The different interventions were evaluated and the most promising were selected. This paragraph will elaborate on the different chosen interventions and how they result in less packaging waste in the future.

Milk packaging

The ideas in the milk packaging section that were selected mention a refill system for milk and introducing oat milk powder. Supplying milk in bulk and letting tenants refill their reusable jugs leads to less packaging that is needed to supply this milk. Oat milk powder is the dried form of oat milk and is in volume and weight lower, leading to less packaging per liter than the cow milk used now. Furthermore producing oat milk powder has a lower footprint to produce than cow milk.

Single-use pallets

Interventions that are proposed are bulk buying, working with suppliers to supply in gitterboxes or reusable crates, challenging suppliers to combine product deliveries, and asking for unpacking at their warehouses.

Asking suppliers to combine deliveries and unpack in their warehouse leads to less waste at Oslo Airport since the products can be delivered in reusable packaging solutions. However, this is labor-intensive for the supplier, thus a costly intervention. There has to be an incentive as to why the supplier would do this, such as the costs being covered by the client, regulations, or clear benefits.

Furthermore, it was uncovered during the tenant rounds that the source of single-use pallets is hard to identify. The only source that was found was furniture, therefore it is proposed to introduce modular furniture for stores, provided by Avinor. This way there is no need to import furniture and other decorations for stores on single-use pallets, thus decreasing this packaging waste stream**.**

Cardboard packaging

The first proposed interventions are overarching with the ones from the single-use pallets. Namely, bulk buying, working with suppliers to supply in gitterboxes or reusable crates, challenging suppliers to combine product deliveries and asking for unpacking at their warehouses. Furthermore, it proposes to make use of smart packaging solutions that can create custom-sized cardboard boxes per delivery. This way there is no transport of air and the amount of cardboard that is used is optimized (Sparck Technologies, 2024) .

Plastic foil

Firstly the same overarching interventions as mentioned previously are proposed. Particular to the area of plastic foil is challenging suppliers to use less or alternatives. For instance, using thinner plastic foil and biodegradable or compostable alternatives as these lead to a lower CO2 footprint. Reusable alternatives often weigh more, but as there are ongoing developments in this area it is proposed to use a circular alternative in the future as this eliminates waste. The time to do this is not set but stakeholders need to keep their eyes open for advancements in the industry and constantly evaluate whether this could be applied to reduce the CO2 footprint.

Secondary packaging

Firstly the same overarching interventions as mentioned previously are proposed. The proposed interventions in this area are focussed on the secondary packaging of drinks, as this area came forward during the observations as a big contributor to secondary packaging waste. It proposes to eliminate the sales of water bottles and sodas, but use water tapping points and syrups to mix sodas. This requires users to take their bottles from home, thus leading to the elimination of the product and packaging in its entirety.

Reuse area design/layout

It is proposed to introduce new signage, warehouse racks, and a new layout in the near future. Thereafter digital signs and robotics to structure the warehouse. These solutions aid the introduction of new circular alternatives as they can increase the trust between suppliers by providing traceability of the circular packaging solutions and increase capacity and efficiency in the warehouse. Furthermore, it minimizes wrong sorting, contributing to a decrease in packaging waste as some circular packaging solutions currently end up in waste.

Communication

Various ideas, such as regular meetings and assigning packaging representatives are proposed. All proposed interventions help to increase communication between stakeholders. Communication came forward as one of the essential elements to increase sustainable packaging practices in the research described in the discover section of this report.

Other interventions

Lastly, there are some other interventions outside of these problem areas that are proposed. These include forcing suppliers to put return or reuse information on the packaging, introducing a centralized cleaning supply with sustainable powdered or concentrated cleaning products, using digital tags and introducing a too-good-to-go platform for packaging. Setting up a too-good-to-go platform for packaging is proposed as it was found that certain items that are thrown away, such as boxes from Shop 1 are still fit for storage purposes. Currently, various F&B units use the reusable crates provided by suppliers 1 and 2 to store products. This means there is a demand for these types of boxes or crates that are fit for storage. Therefore it would be beneficial to offer them to each other, before throwing them in the waste.

Concept roadmap for testing

To test the roadmap an initial simplified roadmap to tackle the problem areas was made. Due to time constraints, the testing at Oslo Airport was not done with the final roadmap.

In the initial simplified roadmap (Figure 63) the problem areas are presented at the bottom and the future vision is presented at the top. The time flow is from the bottom (present) to the top (2050). Therefore light green area presents more short-term interventions and dark green the longer-term interventions, the ombre of green represents a flow from present to future. The purple boxes represent needed innovations or research to get to the goal/intervention and the blue boxes present possible partners for the interventions. The column “other” is not presented in chronological order, but presents interventions that do not fit with any of the problem areas but also reduce waste.

Future vision

Milk is made on demand at Oslo airport with the help of lab grown diary, in this way the supply is local and without the use of animals

Integrate lab grown diary, and as it has the lowest CO2 footprint it makes it the least expensive, thus incentives people to try and pick this

Lab grown dairy/meat

Make the milk options with the higher CO2 footprint more expensive

Make using plant based milk the standard in coffee machines/meals

Promote the choice for plant based milk to travellers through loyalty points, visual encouragement and discounts

Introduce plant based milk powder to commercials

Overherd/Koro/Tine

Introduce milk refill system

Supplier 3

Secondary packaging of drinks through plastic and cardboard as we know it now is obsolete because the primary packaging of drinks is redesigned. sodas are made through mixing water with syrups that come in reusable circular packaging, travellers bring their own cups or bottles

Eliminate store displays showcasing pre made drinks in packaging, only make it on demand in cups/bottles

Incentivise costumers to use their own bottles/cups with discounts, make this routine

Eliminate the sales of single use water bottles and install free water tapping points

join the pipe

Introduce syrups next to regular soda bottles

Products are sourced locally and single use pallets cannot be found at the airport, since all the pallets that are used are circular and single use wooden pallets are banned.

Introduce modular funiture for the decor of stores, which comes from local/upcycled sources

Impose a ban on products coming in from outside of the EU

Stimulate communication and go towards local alternatives for products such as furniture, decor, food and beverages

Work with suppliers to supply in gitterboxes or reusable crates

Through our local supply chains products come in in reusable packaging, making cardboard packaging limited. If cardboard packaging is still used for the protection of certain goods, it is CO2 neutral.

deliveries are done with reusable packaging

Constantly re-evaluate incoming products and packaging to be alert about when circular packaging becomes beneficial

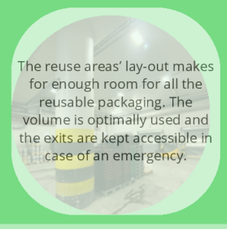
Prepare for the adaption of supply chains with suppliers

Work with smart packaging solutions to limit excessive use of cardboard

Stimulate bulk buying and work with suppliers to make this possible for commercials

Challenge suppliers on combining products/deliveries and ask for unpackaing at their warehouse if applicable

Work with suppliers to supply in gitterboxes or reusable crates



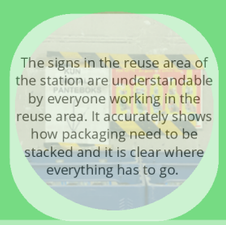
The reuse areas' lay-out makes for enough room for all the reusable packaging. The volume is optimally used and the exits are kept accessible in case of an emergency.

digital tags & passports

Opt for foldable reusable packaging solutions with stakeholders to be able to store more packaging

Use the height of the space and label layout

Use the height of the space and label layout



The signs in the reuse area of the station are understandable by everyone working in the reuse area. It accurately shows how packaging need to be stacked and it is clear where everything has to go.

Elimination of wrong sorting via robots who supply, return and handle the waste handling instead of people

Digitalize boards for easy alteration and expansion

Signage on the ground/walls and board

Introduce new clear signage with a correspongding colour coding at the waste stations

Plastic packaging foils are replaced by a sustainable circular alternative. Because of the local supply chain the transport distances are lower and the sustainable alternatives become more eco friendly than the single use alternative.

A lightweight alternative to plastic packaging foil that fulfills the same putpose

Impose regulations on packaging foil thickness

Challenge suppliers to use thinner packaging foil

Challenge suppliers to use less packaging foil

Work with suppliers to supply in gitterboxes or reusable crates

There is open communication between all stakeholders and together they actively collaborate constantly to find the most eco friendly packaging alternatives and minimize waste over the whole supply chain.

Organize half way meetup week, a week in which different stakeholders can follow workshop, discuss the next years and exchange ideas

Stimulate local sourcing to be able to communicate throughout the whole supply chain, making it easier to collaborate

Monthly meetings and informal events to promote communication

Make it obligiatory for new commercial workers to visit RP19 as part of training and see how return items & waste are sorted

Trainings and input sessions for warehouse personel

Other ways to reduce packaging waste

set up a warehouse outside of the airport where certain products can be unpacked

provide reuse information in packaging

Make an internal too good too go concept for packaging items, so it can be reused by other commercials, travellers or by local businesses and people

Use EU legislation and own legislation and policies to limit packaging waste and oblige more reusable solutions in certain focus areas

Reduction/elimination of take away pakaging and single use packaging for food and beverage items will also lead to less packaging waste for the supply of these products

Centralized cleaning product supply made through powders and syrups

Perform an analysis on waste from cleaning products to get an effective overview of waste reduction and financial benefits, to incentivise commercials

Problem area

OTHER

Figure 63: concept roadmap for testing and evaluation

Roadmap Visualization

To translate the outcome of the mapping sessions into a visual roadmap I applied different visualization methods. Different concepts for the flow of the visualization were made and evaluated regarding the visualization of the roadmap. To develop the roadmap different questions have to first be answered as described in Simonse, L. (2018);

- Who is the target audience
  - Avinor
  - Tenant hosts/tenants (to get them to understand decisions that are made)
  - (Travellers)
- How will the roadmap be presented
  - working document in PDF, Canva and PowerPoint format
- What is the goal of the roadmap
  - Inform and activate

Thereafter inspiration was gathered and sketching was done, which can be seen in Figure 64. These sketches were translated into 2 visual concepts, which can be seen in the testing chapter in Figure 65.

To graphically make attractive and effective roadmaps the AIDA and 3-30-300 rule are useful tools to apply, see Figure 66 (Haans, 2021).

To test the effectiveness of the roadmap, different requirements were set. These can be seen in Table 7.

Figure 64: Inspiration gathering

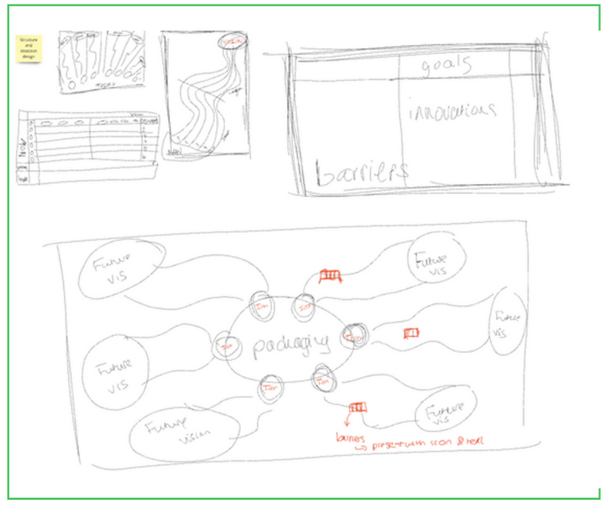


Figure 65: Roadmap flow ideation

Requirements roadmap	
1	The roadmap should have a clear structure & flow meaning: • Upon first glance, it should be noticeable what the topic is in 3 seconds • In 30 seconds the overall flow of the roadmap should be clear • in 300 seconds the main information has to be able to be read See Figure 66
2	The roadmap should fit with the grapic style of Avinor and TULIPS.
3	The roadmap uses icons and symbols that are uniformally understandable
4	It should be clear how and why the interventions are beneficial for a more sustainable future
5	The roadmap should be inspiring

Table 7: requirements for the roadmap

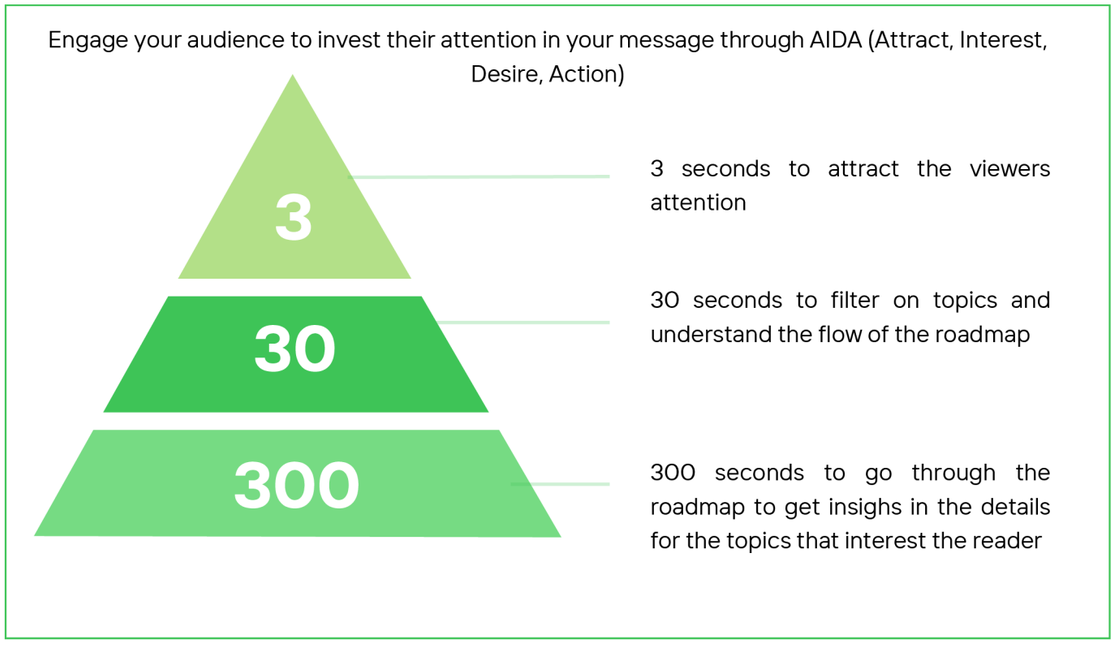


Figure 66: 3-30-300 rule for graphic design, adapted from Haans, (2021)

Additional research

Since milk carton waste was another area of interest for the concept additional research was done in this area. Moreover, it is one of the interventions Avinor is looking to implement, therefore it is added to this report.

Milk refill/Powder goal

For the refill/powdered milk a design goal was set:

"The design will reduce the volume of milk Packaging waste at Oslo airport during operations, while keeping operations running with at least the same efficiency, while maintaining product quality and safety, within one year. "

The CO2 footprint of milk

Norwegian milk has a CO2 footprint of 1.04 kg CO2eq/liter (supplier 3, 2023). To compare this to oatmilk the footprint of Oatly barista drink was taken, since they provide numbers based on location. They researched the CO2 eq of oat milk in Norway, Sweden, and Denmark and that came to be 0.36 kg CO_2e/kg (Oatly, 2024). This means that the oatly liquid-based alternative would already result in a reduction of 65.38% in CO2 emissions for the same amount of liters as cow milk. The outcomes of a study by Figure Poore & Nemecek, (2018) are shown in Figure 67. In this Figure, we see cow milk being compared to other alternatives.

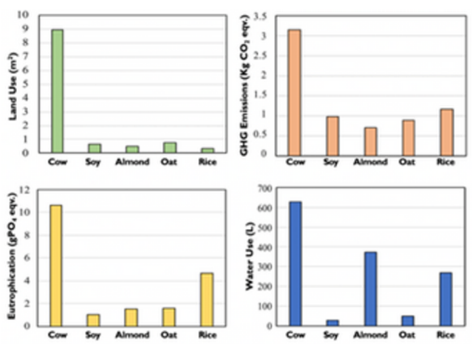


Figure 67:Comparison of the environmental impacts of different plant-based milk alternatives and cow's milk. Adapted from (Poore & Nemecek, 2018), retrieved from https://oxsci.org/future-of-dairy/

Oat milk powder

During research, an interesting product segment came up that could lead to a massive reduction in packaging material. Oat milk powder could reduce CO2 footprint and due to the milk being transported and supplied in powder form, it leads to a reduction in transport CO2 emissions.

Contact was established with Overherd, an English brand of powdered oat milk. They estimate that the CO2 emissions of oat milk powder are 25% lower than regular oat milk. Furthermore, they mentioned that one of the other big benefits is the shelf life. A huge amount of regular oat milk goes to waste due to spoiling, whereas oat milk powder can be stored so it is virtually food waste-free. This increases the carbon saving even more but is harder to measure. The costs of oat milk powder are also lower.

Milk consumption

In Norway, milk has traditionally been and still is a central component of most people's diet, and it holds a strong position in Norwegian nutrition policies. However, milk consumption growth is decreasing (Henjum et al., 2021). The size and growth of the cow's milk market can be seen in Figure 68. The size and the growth of the milk alternatives market can be seen in Figure 69.

Supplier 3 and (oat) alternative to cow milk

supplier 3 has their own brand when it comes to oat milk, in their plant-based product line, called GRYR. Since 2022 the oats have so far been supplied by Norwegian farmers, however, the production currently takes place in Sweden (Mejerimedier, 2022). This is important to note since this makes transportation emissions high for the milk alternative compared to Norwegian locally produced milk. supplier 3 could be a potential partner, to make the production of this oat milk powder possible, but this has to be discussed with them.

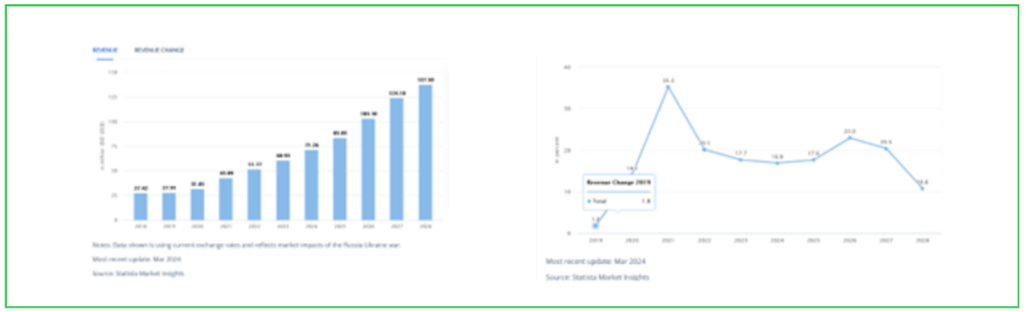


Figure 68: milk substitute market revenue and revenue change retrieved from https://www.statista.com/outlook/cmo/food/dairy-products-eggs/milk-substitutes/norway#revenue

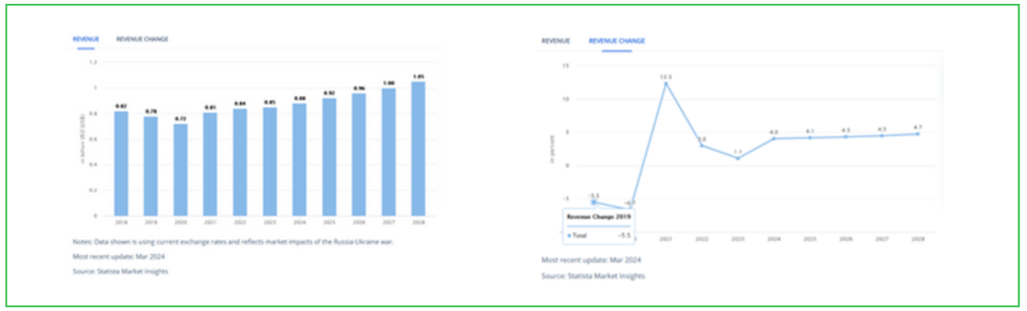


Figure 69: milk market revenue and revenue change retrieved from https://www.statista.com/outlook/cmo/food/dairy-products-eggs/milk-substitutes/norway#revenue

Storyboards

To be able to test these potential solutions and analyze willingness to apply the concepts in real life, a packaging mock-up and three storyboards were made to present to tenants, see Figures 70, 71, 72 and 73. Willingness is a factor Avinor was especially interested in, as they often find commercials are not willing to adapt the implement the solutions they come up with.

Milk powder

Milk powder with which 1 liter of milk can be made was also bought to physically show the tenants what it looks like and how much smaller the volume of the product is compared to a milk carton. The tenants were impressed by the small amount of powder that was needed to make 1 liter of oat milk and it helped them to understand the difference it could make in packaging waste and see why it would be positive to implement.

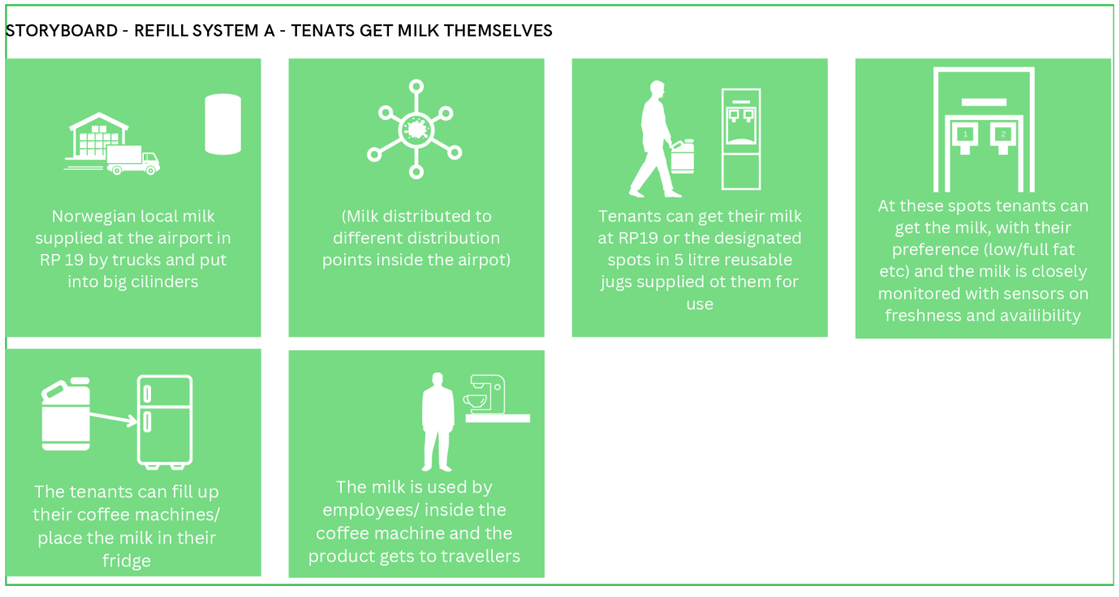


Figure 70: storyboard milk refill system 1

Figure 71: storyboard milk refill system 2

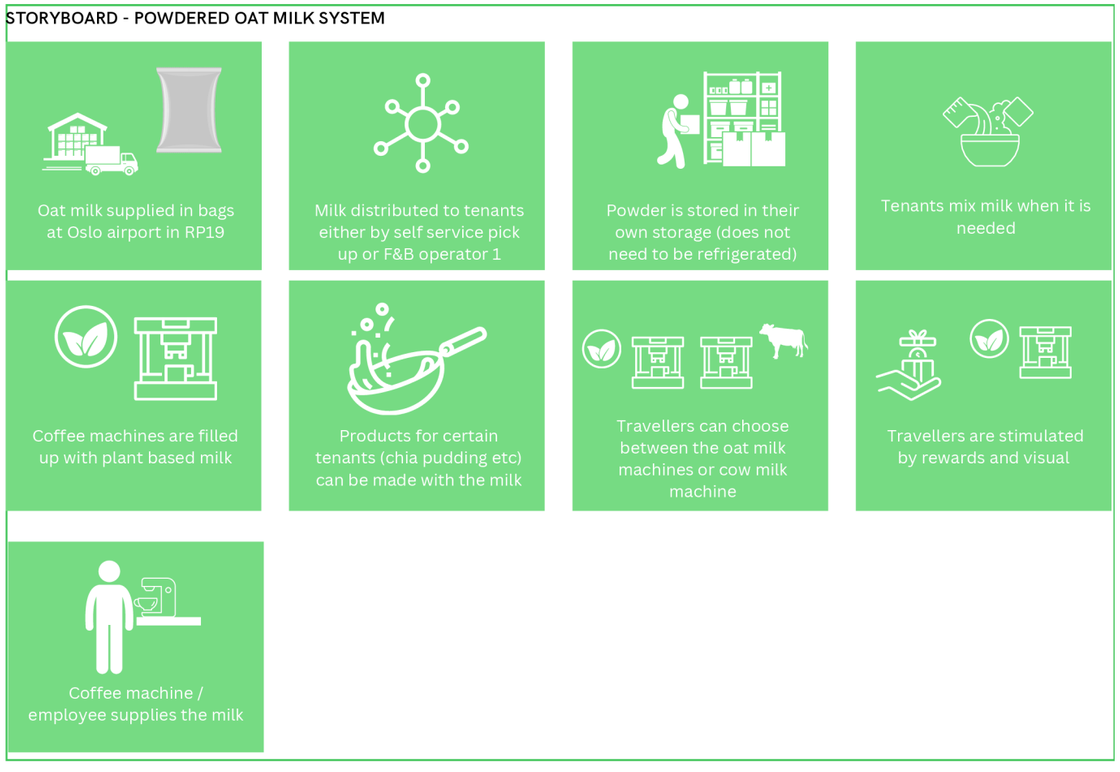


Figure 72: storyboard oat milk powder

Figure 73: oat powder packaging concept

Roadmap testing

This chapter elaborates on the testing of the roadmap. This chapter consists of two different topics. The first part discusses the interviews that were held to evaluate the ideas that are present in the roadmap. The second part discusses the testing of different concept roadmaps according to the requirements set in the previous chapter.

Idea evaluation

Through discussing the initial ideas and future visions with Avinor the need to test the willingness of commercial units to implement the interventions of the roadmap was emphasized. To uncover this interviews were held with stakeholders.

The ideas that were discussed in these validation interviews are;

- refill system for milk
- powdered oat milk
- elimination of water bottles and syrups instead of plastic bottles
- modular interior
- cleaning product powders
- bulk buying of products
- obligatory visits to RP19 for new employees of tenants to see how packaging return items are stored
- too good to go for packaging that can still be used

The ideas were evaluated through an in-depth interview with an F&B operator 1 food and beverage worker. Furthermore, the roadmap and ideas were also presented to an F&B operator 1 environmental representative, since Avinor needs them to collaborate on tackling these issues as they are an essential player in their communication with suppliers.

A description of the setup and the transcriptions of the interviews can be found in Appendix H.

F&B operator 1 food and beverage worker

Different barriers to the acceptance of the design interventions for commercial workers were uncovered through testing.

Refill system for milk: this could work, but there would need to be a washing system in place and the milk would need to be delivered to the stores as many stores cannot do that themselves.

Eliminating water bottles and using syrups for sodas: the main concern is hygiene. The workers would need to fill the cups for the people coming by, as their contaminated bottles are not allowed to touch the dispensers due to hygiene rules. Therefore they would need to keep an eye out for this.

Modular interior: It was mentioned that she sees it as a good investment, but in the tenant contracts Avinor also asks for the whole brand package surrounding the food & beverage concept, and with the tender competitions this would not be beneficial to win them.

Cleaning product powders: positive towards using powders for cleaning, the effectiveness of the product just needs to be on point

Bulk buying of products: Is okay as long as it fits in their fridges and fits the demand of the unit, but not all units use the same amount of a product. Therefore it does not apply to all.

Obligatory visits to RP19: Would be okay if Avinor hosts it since there is no time for them to do it and their onboarding already takes a long time.

Too good to go for packaging: She would see it working for pallets, but not for cardboard boxes as she crushes them to fit in their waste containers.

F&B operator 1 environmental representative

The goal of the interview with the F&B operator 1 environmental representative was to uncover the extent to which they are willing to communicate with other tenant host competitors and to identify barriers to cooperation. In the interview, similar barriers as in the interview with the food and beverage worker were mentioned for their personnel, such as lack of time and costs.

The main insight was that the vision on the roadmap aligns with their sustainability agenda and that they are inspired by the same problem areas. They are willing to cooperate with Avinor and their units to foster more sustainable practices. However, meetups with competitors such as F&B Operator 2 were not seen as feasible. As the tender competition at Oslo Airport is high to them and sustainability plans are a way to set you apart from your competition. Therefore they do not see open communication between them and F&B operator 2 happening.

The last insight was that they are heavily reliant on their current suppliers. The amount of goods they order is so high and their current suppliers e are the only ones that can deliver this in Norway. Therefore they cannot switch to another supplier, even if another supplier has more sustainable packaging.

Tenant rounds

Furthermore, during visit 2 various employees of different commercial units were briefly asked what their opinions were toward the different interventions when walking around the terminal. In confidential Appendix G4 a table with the outcomes can be seen. The main barriers that were identified by these conversations are listed in the next paragraphs.

Barriers to bulk buying

The biggest barrier to integrating buying bulk for F&B tenant workers is the ease of handling. An example is how 1-liter cartons of milk are less heavy. Furthermore, the 1-liter packaging fits perfectly in their fridge, allowing for optimal volumes and storage. The same holds for other products that they use. The ease of handling has to be the same for larger volumes for tenants to

consider switching to larger packaging sizes.

Barriers to implementing a milk refill system
The biggest barriers are lack of time, concerns about hygiene, and lack of employees.

Barriers to using powder oat milk
The biggest barriers are lack of time to mix the powder with water and concerns about quality. Next to that plant-based milk still costs extra for travelers at various stores and some stores, such as the shops from F&B operator 4, do not even offer the option. Moreover, the powder product should not cost more than the current milk currently offered. If the cost benefits outweigh the extra time costs it might be considered more.

Some immediate ideas to overcome these barriers were mentioned during the short conversations by tenant workers. For instance, if Avinor/F&B operator 1 would provide the (oat)milk premixed/prefilled then there would be no problem for commercials to use it. The milk could be brought around by a "milkman" team. They also saw a benefit to implementing this; if this team could fill up the coffee machines directly, it would result in needing to store less milk at the food & beverage stations, which benefits them as there is already a lack of space.

Branding as a barrier
It was also mentioned multiple times that commercial units have partnerships with certain brands, making it impossible to work with local suppliers and needing their branding on certain packaging items, making it hard to implement a circular alternative for these packaging items.

Roadmap concept testing

To evaluate the graphic design of the roadmap and the effectiveness the concept roadmaps, as seen in Figures 74 and 75 were tested.

To test requirements 1,3, 4, and 5, 3 people were approached and asked to view the roadmap and report on their thoughts, see Appendix H.

Various insights were provided by the participants;

- Roadmap 1 was followed from the top to the bottom by all participants, meaning it was not clear that the roadmap displays the evolution from the bottom up. This was not visible within 30 seconds.
- Roadmap 2 was clear and understandable within the time limits set by requirement 1 to all participants, it was overall preferred
- Icons were clear
- It was unclear how every intervention led to a more sustainable packaging future
- 2 participants mentioned that there was too much information on the roadmap, and they were a bit overwhelmed when starting the exercise
- Both looked visually appealing to the participants, but Roadmap 2 was clearer
- 2 participants mentioned Roadmap 1 looked more playful/fun, and thus they found this one more inspiring

Conclusion roadmap testing

Currently, roadmap 2 was preferred by participants, due to its legibility and this roadmap currently scores higher on design requirement number 1 and 4. Both maps score equally high on requirement number 3. Roadmap 1 scores higher on requirement number 5.

In this roadmap 2 fits better with the design requirements tested with users. However, roadmap 1 fits better with the TULIPS graphic style. After discussing both roadmaps with the supervisory team, it was decided to move on with concept number 1, but add more context in the form of visualizations and metaphors to guide the reader better and enrich the roadmap.

Roadmap visualization concept 1

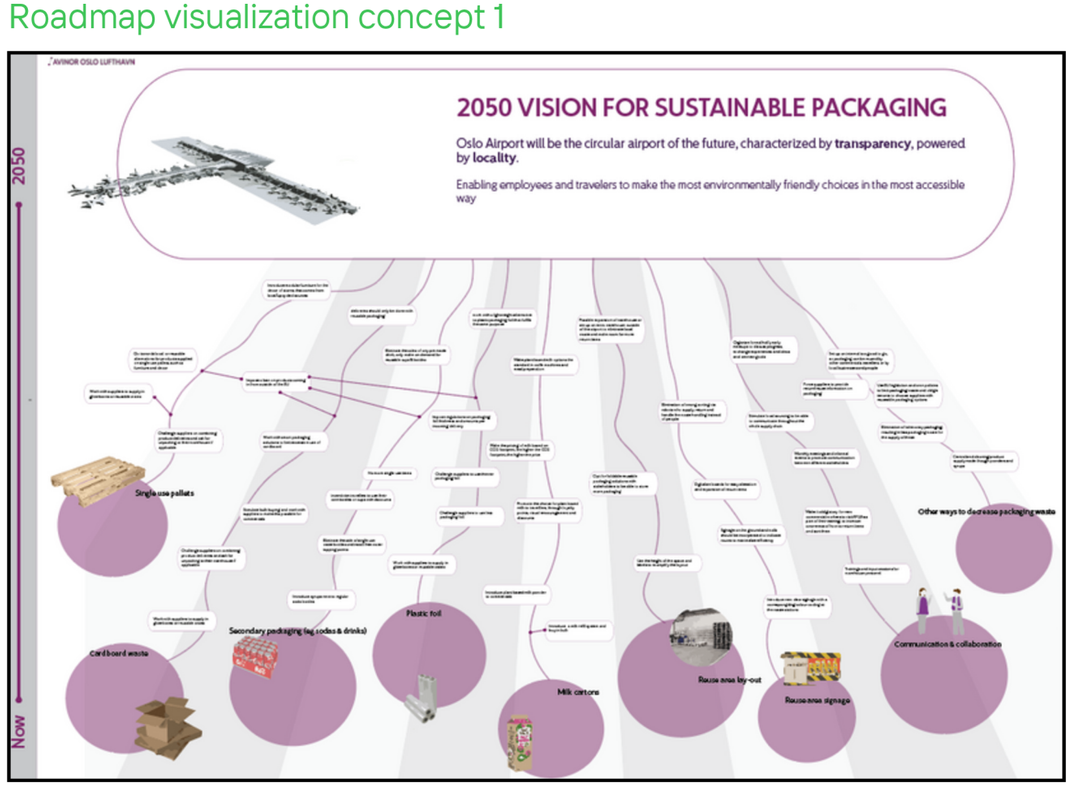


Figure 74: Roadmap concept 1

Roadmap visualization concept 2

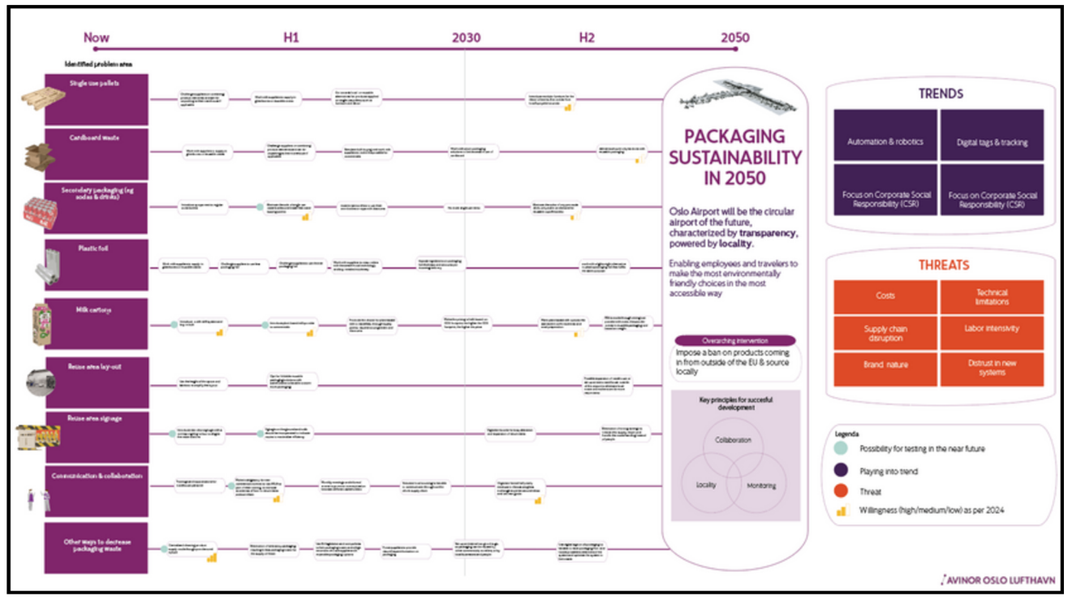


Figure 75: Roadmap concept 2

Key Insights - Roadmap testing

- The ideas in the roadmap got different reactions, multiple themes arose from the interviews for the barriers to adopting different interventions;
  - Labor intensity & lack of time
  - Hygiene concerns
  - Quality concerns
- Through supplying certain products by a team from Avinor, the time and labor intensity barrier could be taken away
- Tender competition leads to the need to differentiate as a brand, this is imposed by Avinor, but leads to the need for branded packaging
- There are limited suppliers to choose from in Norway and quantities of food that must be ordered are large. This means that suppliers like supplier 1/2/3 have a monopoly in the market
- The final roadmap will resemble the first concept, but more context will be added to examplify the flow

Phase 4

D E L I V E R

Final concept

In this chapter, the final concept is presented. It will start with a QR code to a video of the concept and show renders, thereafter it presents a storyboard.

To present the final concept the space was built in Rhino and rendered in Twinmotion. In this, the wayfinding and elements, which can be seen in Figure 76, of the redesign were added. The QR code in the confidential Appendix section J2 can be scanned to view the concept video made while walking through RP19.

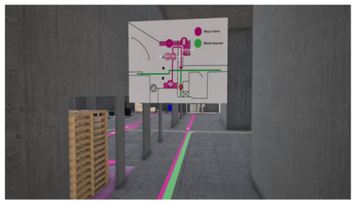
Many different elements to clarify the flow and structure of the warehouse are used in the concept. As partners, such as suppliers are confidential, they are censored in the images in this section of the report, but the full images can be seen in the confidential Appendix section J1.

Last validation

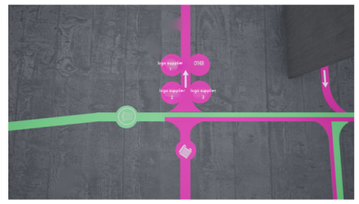
As a last validation the VR warehouse concept was tested by 5 people in Delft, see Appendix H for the setup and plan. With the Twinmotion model it was possible to walk through the warehouse virtually.

In this testing, the participant was shown a return item or waste and asked to return it where it was supposed to be disposed of or returned to. This research showed one concrete improvement. Namely that the information board at the entrance needed to be lowered and that the font needed to be bigger. It also showed that the wayfinding signage on the ground was an essential element of finding where products had to be returned as these lines gave the most cues to participants on where to go to. The full testing plan and outcome can be seen in Appendix H. The results were integrated into the final concept.

Figure 78 presents renders of the final design for RP19 and shows how elements integrate different aspects of the research. Figure 77 shows the locations in the warehouse of the renders in Figure 78.



Information boards (upon entering the waste station)



Floor signage with icons & lines for wayfinding

All elements use color coding to clearly distinguish waste from return items!

Wall signage and lines to sperate items per supplier

Boards per return item & floor blocking elements so spaces are kept free

Figure 76: redesign elements

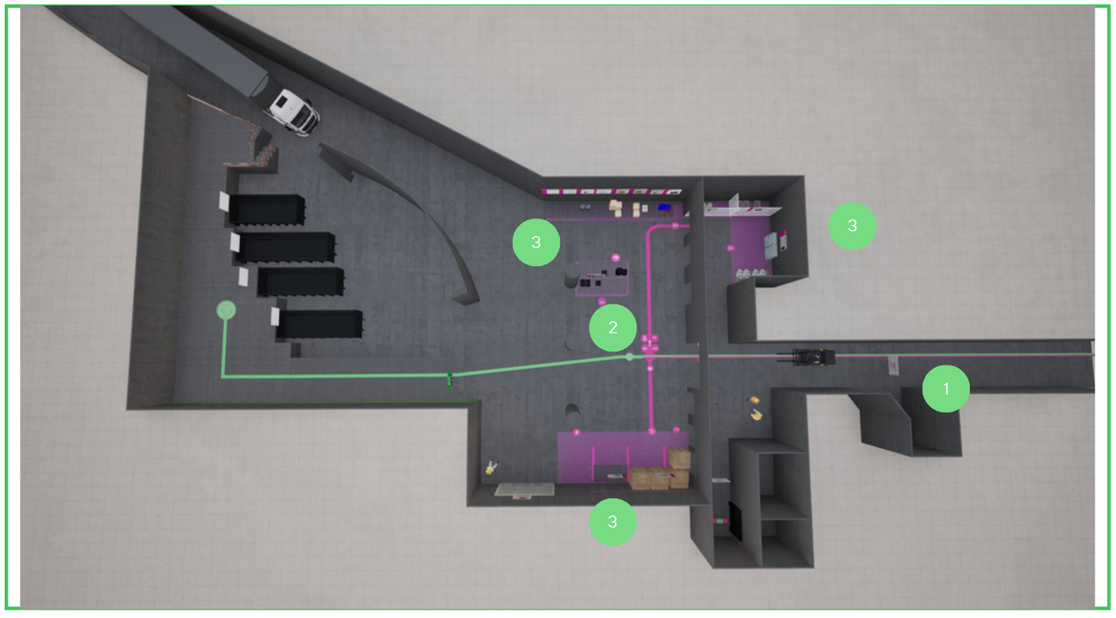
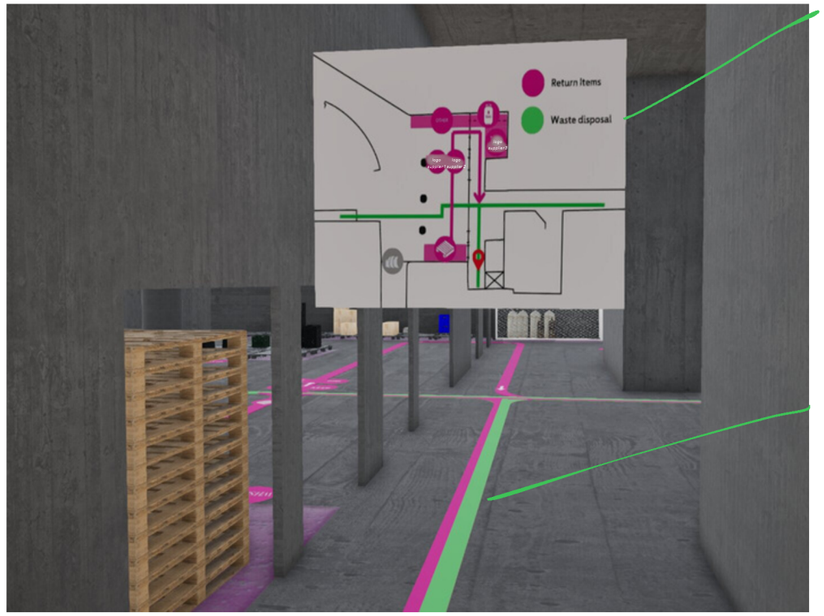


Figure 77: final concept mapping

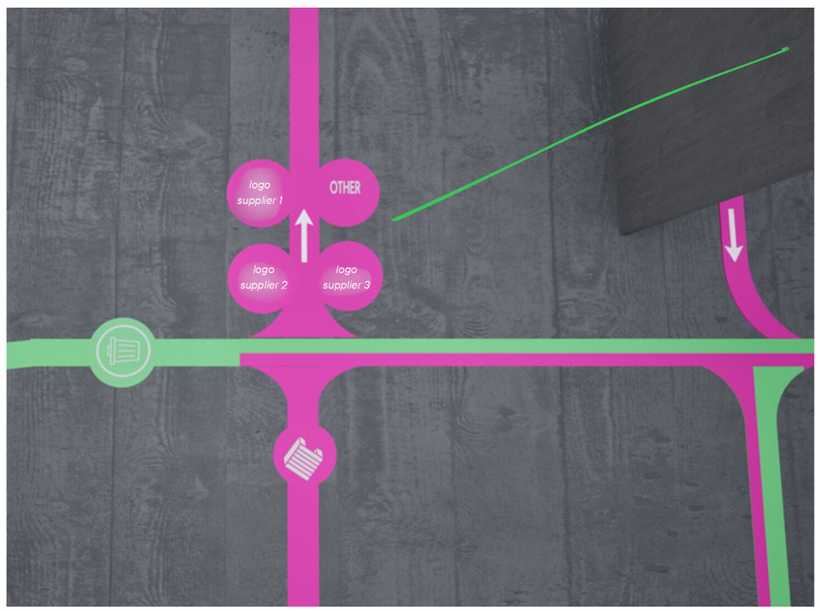
1. *When entering the warehouse*



Signage right upon entering the waste station is integrated and hanging from the ceiling, it shows the different areas, colour coding and what item/supplier goes where.

Vinyl floor signage showcasing the different routes. Pink stands for return and green for waste, at first both lines are shown, later they are split.

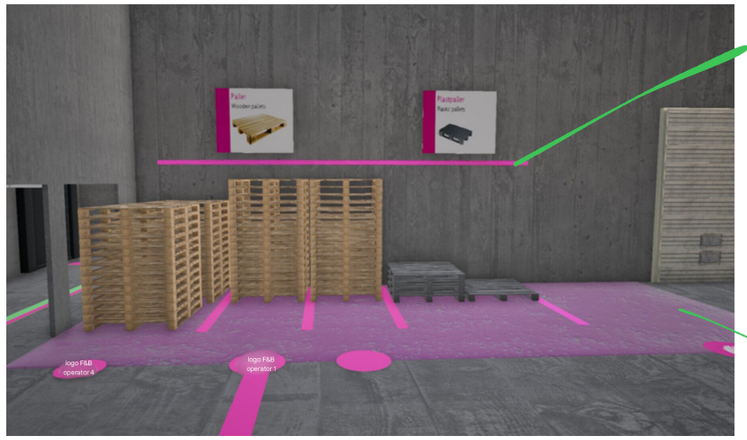
2. *When finding your way*



Icons showcase what goes where with arrows and the orientation is set to the right direction. The icons and suppliers were understood in testing. However testing has show it is needed to know which return items belong to what supplier. This needs to be part of the warehouse personel training.

The signs on the ground are made from vinyl and if the type of return items changes they can be covered with new stickers. This way the space can be altered to fit future developments.

3. *When putting away your return items*



Signage on the wall indicates ideal stacking height for items to fit into trucks.

Ground blocks for return items and extra floor signage to devide this space up per supplier so pallets do not get mixed up.

Boards explaining which item goes where and for supplier 1 crates it is ephasized that they have to be sorted per color.

Repeated ground signage to show which item goes where

Figure 78: final concept part 2

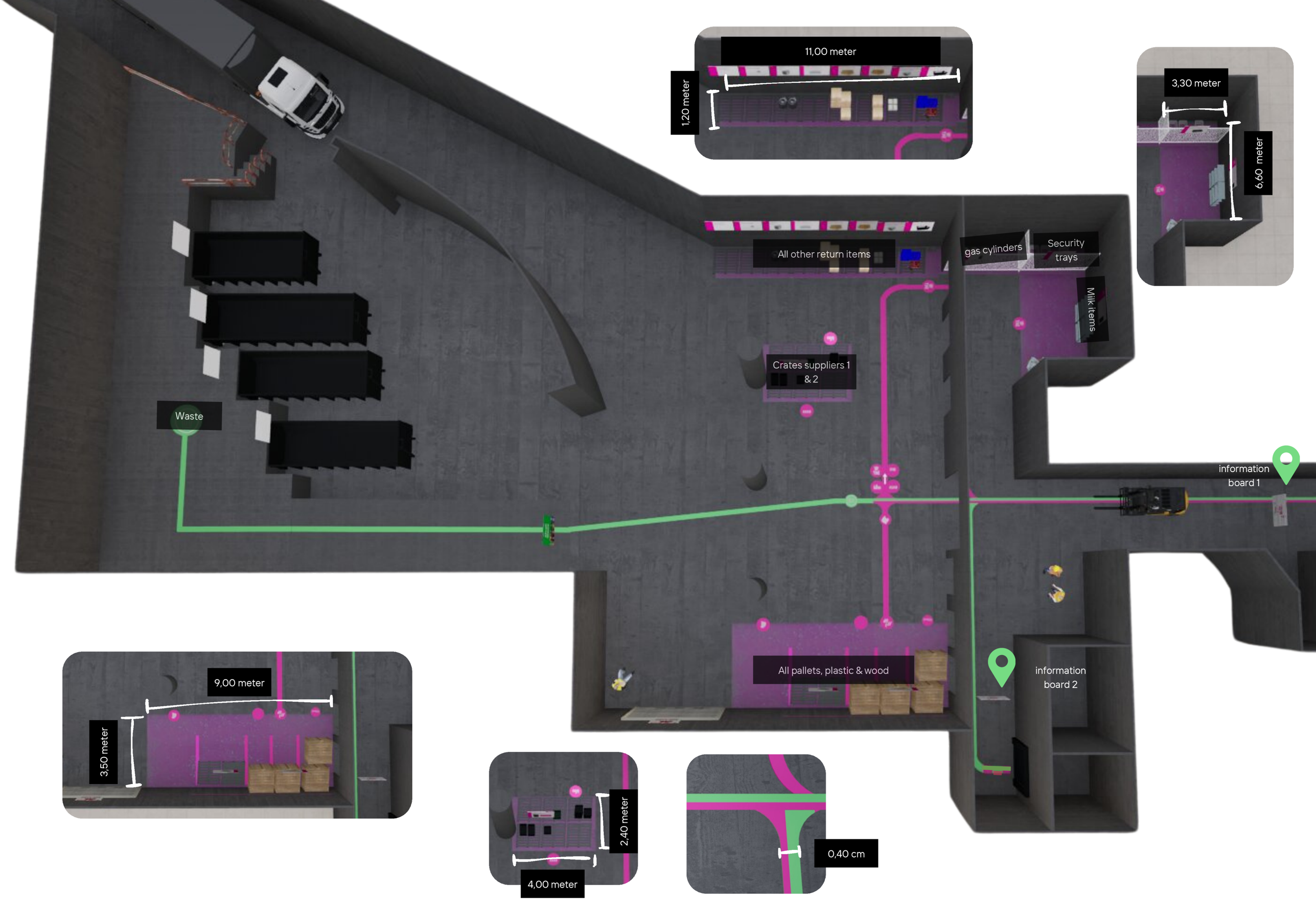


Figure 79: mapping of ground signage

Detailing

Floor plan

Figure 79 shows the concept from the top with ground markings (blocks and lines) with measurements. The locations of the return items are also presented in this Figure.

Board dimensions

The boards in the warehouse will have a size of 120 CM by 100 CM. This makes for enough space on the boards to show the item, Norwegian name and English translation clearly. The font size of the wording will have a minimum height of 9 cm, making the text legible from at least 15 meters away according to Table 6. The dimensions and template to make these boards can be seen in Figure 80. The template was made to ensure that the boards would be consistent and comply with the design requirements found in the paper of Rodrigues et al. (2018).

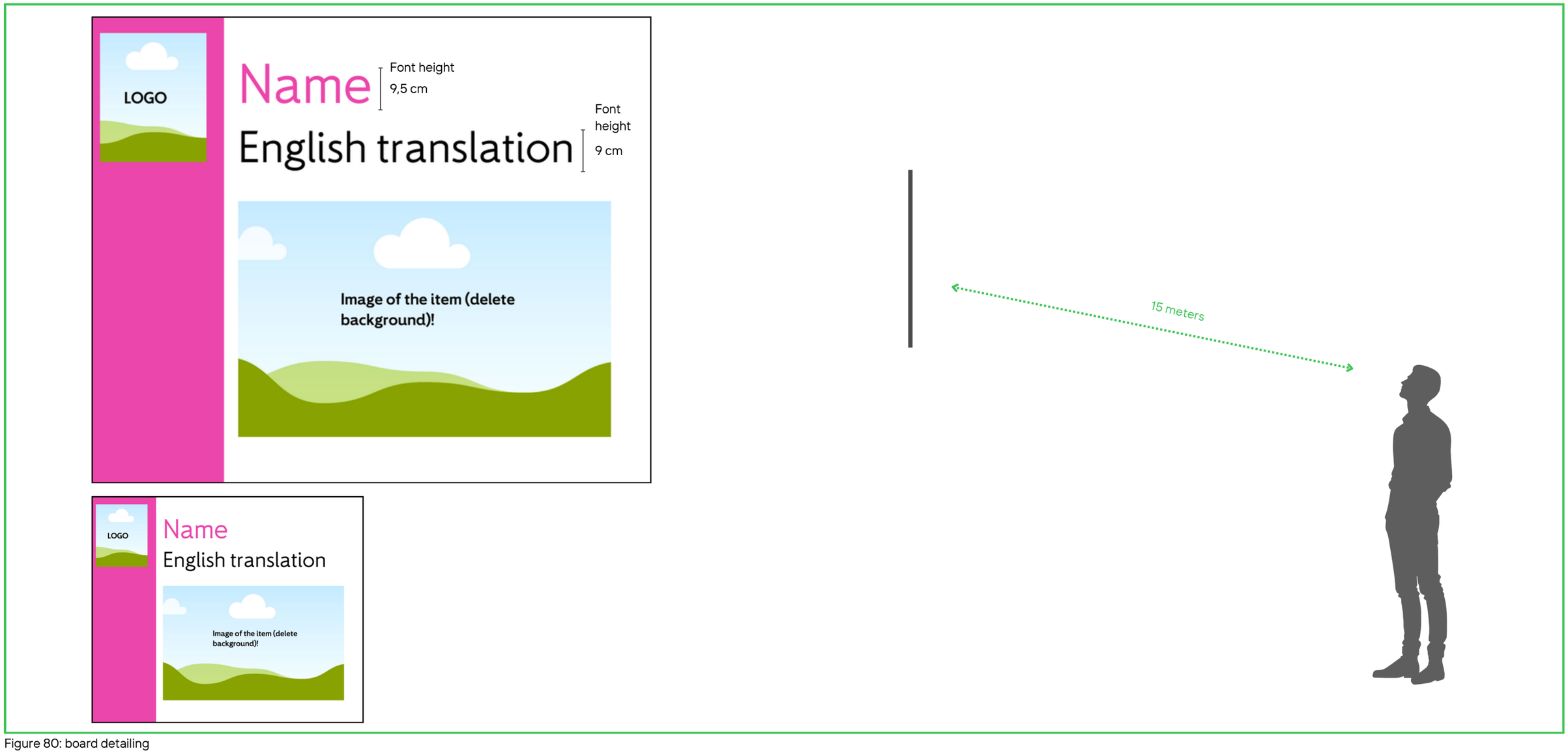


Figure 80: board detailing

Final Roadmap

In this chapter of the report, the final roadmap is presented after the feedback rounds from stakeholders. The Roadmap integrates the different problem areas and presents interventions to reach the desired goals.

To minimize packaging waste and go towards the goal of net-zero three principles have been identified that play an essential role.

These principles are reflection, collaboration, and locality, see Figure 81. The final roadmap presents different interventions, however, to successfully implement the interventions the three principles play an essential role and must be taken into account. For Avinor and tenants, this means collaborating with eachother, collaborating with suppliers, sourcing locally, and reflecting together on the progress that has been made. Therefore the roadmap should also be a working document and will be delivered to the client as a document that they can make changes to. The Roadmaps visualization is carefully thought out through metaphors.

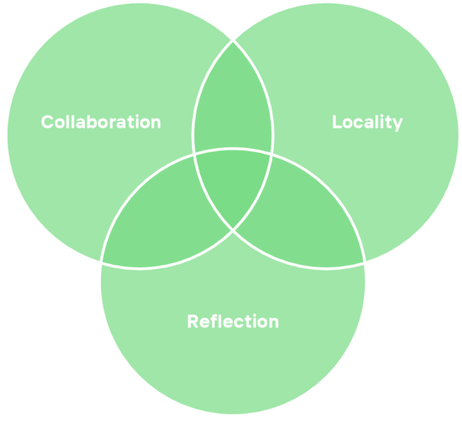


Figure 81:The three principles for a succesful roadmap inplementation

The graphic design decisions are based on the TULIPS graphic style mixed with the Avinor branding, see Figure 82. The metaphors and graphic elements seen in the roadmap are elaborated in Figure 84. The final roadmap can be seen in the next two pages.

To elaborate on the different problem areas more in-depth spreads were made in a style similar to the roadmap. These spreads present information on the willingness of tenants to implement the design interventions, investment costs, and barriers, as requested by the client. The legend that belongs to these spreads can be seen in Figure 83.

These spreads will be attached to the roadmap, as a single document. However, they are specific for Avinor and are meant to be used internally.

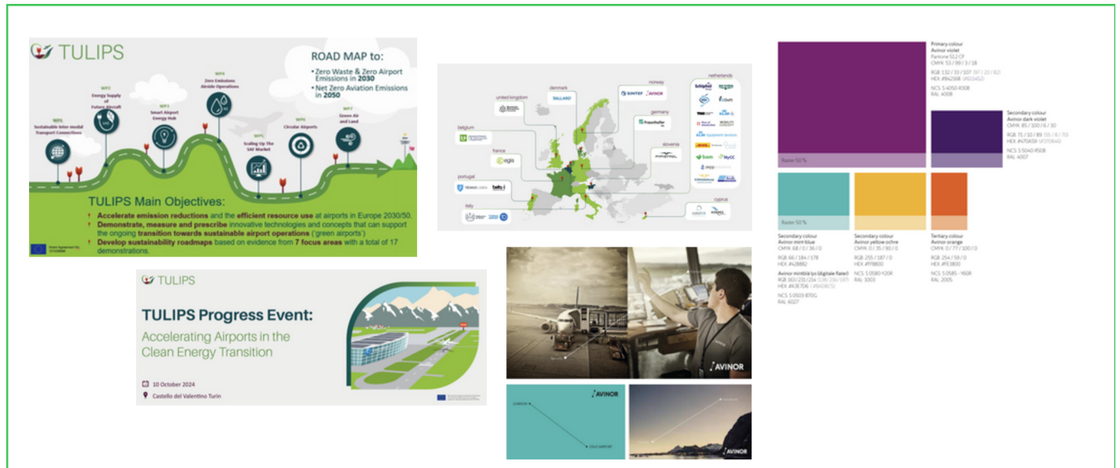


Figure 82: Tulips and Avinor style

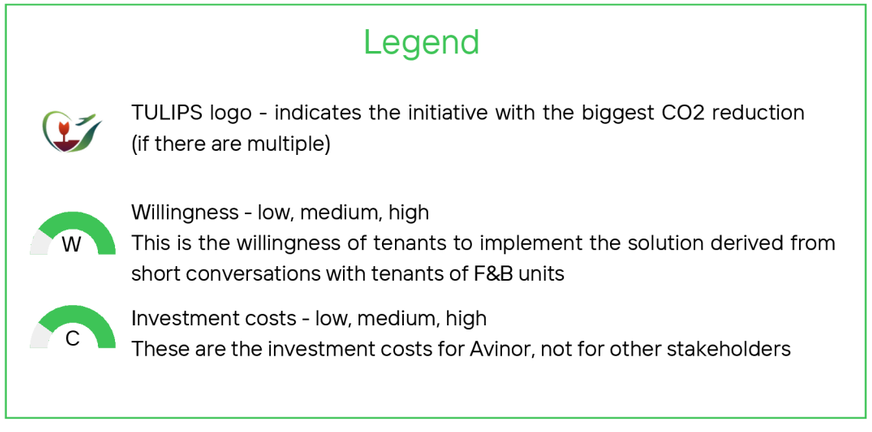


Figure 83: Ledgend for spreads per problem area from the roadmap

Graphic design of the roadmap

Colors & typography

Colors & typography are from the Avinor brand, so it is coherent with their style and can be shown in relation to them.

Flowy & bouncy lines

Represent that the change is not set/linear. The process can change over time and is flexible.

Visualization of the airport and a runway

Pairing the roadmap with a visualization of an airplane taking off and the airport next to it gives it direction and clarifies the context of the roadmap. This also makes it playful and fun. It exemplifies that we want to “go” or “travel” to our new destination, packaging sustainability in 2050!

Norway in the clouds

Represents locality and refers back to their heritage as a Norwegian company and airport.

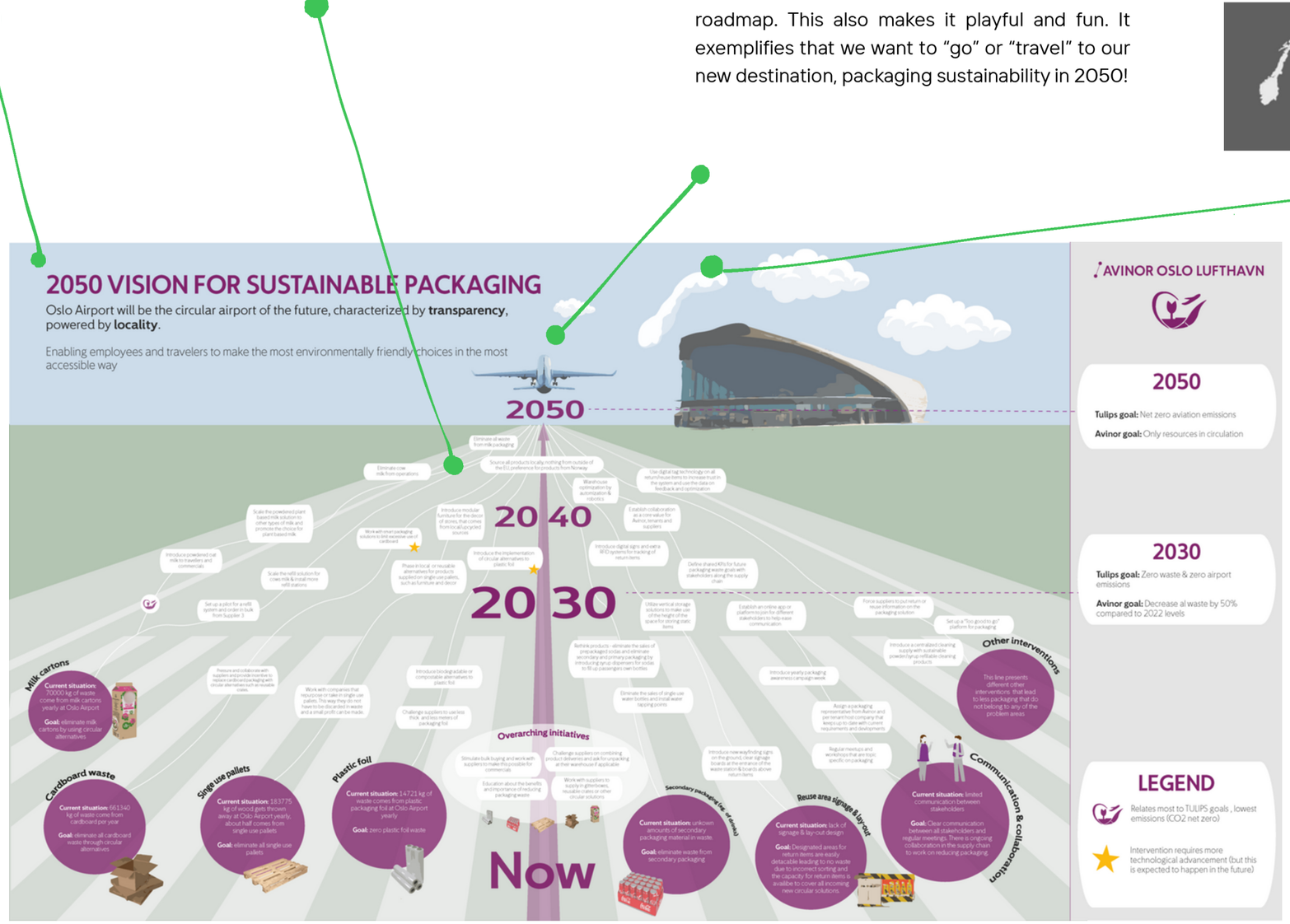


Figure 84: graphic design elements

Final Roadmap

A high-resolution version of the roadmap can be found by scanning the QR code on the top right.

The roadmap will be availible for stakeholders as a PDF and it is recommended to supply it as part of the onboarding package Avinor wants to provide tenants in 2025. Since PDFs are of a high resolution it is possible to zoom in and view every detail. It is recommended to display the roadmap in offices on screens or printed as a poster. Since it is a working document it would be useful to have it on a screen so it can be updated regularly. Figure 85 shows visualizations of how the roadmap could be presented.

Figure 85: presenting the roadmap

Milk cartons

70,000 kg of waste comes from milk cartons thrown away at Oslo Airport yearly.

The CO2 footprint of this is around 6240 Kg/CO2/Year.

The main issue concerning this problem area is the disconnect between the packaging type and the product use.

This route is highlighted with a tulips logo since it presents the solution that decreases CO2 emissions the most, not solely packaging-wise, but for the product from cradle to grave, as it explores a plant-based alternative that has produces less CO2 emissions to make. Thus it aligns most with the overall net zero vision of TULIPS. However, this does not rule out that the two solutions cannot co-exist.

Route 1

Potential savings:
- Bulk buying reduces costs of milk/liter
- Overall CO2 footprint decreases, resuting in lower future costs

Investment costs:
- Reusable jugs/containers
- Cooler
- (Extra personel for supplying)

Barriers:
- Employees and time needed
- Jugs have to fit in the fridge
- Hygiene concerns

Route 2

Potential savings:
- Costs of powdered oatmilk is lower than cow milk per liter
- Overall CO2 footprint decreases, resuting in lower future costs

Investment costs:
- None if the tenants buy and mix the oat milk themselves

Barriers:
- Hygiene
- Taste/quality
- Time and employees needed

Introduce powdered oat milk to travellers and commercials

W C

Scale the powdered plant-based milk solution to other types of plant-based milk and promote the choice for plant-based milk

2030

Eliminate cow milk from operations

2040

Re-evaluate current system and analyze data to enhance

Set up a pilot for a milk refill system and order in bulk from supplier 3

W C

Scale the refill solution and install more refill stations

Integrate digital tracking and app based ordering for optimized supply and inventory tracking

C

2050 vision

No more milk cartons in waste, all deliveries are done using a circular alternative to the milk carton packaging.

Single use pallets

183 775 kg of wood gets thrown away at Oslo Airport yearly. Around half of this comes from single-use pallets.

The CO2 footprint the wood disposal causes is around 2499 Kg/CO2/ Year.

Single use pallets mainly come from imported products outside of the EU. It has also been uncovered that they are used to transport furtiniture and decor for stores.

Overarching interventions (immediate start)

Stimulate bulk buying and work with suppliers to make this possible for commercials

W C

Education about the benefits and importance of reducing packaging waste

C

Work with suppliers to supply in gitterboxes, reusable crates or other circular solutions

C

Challenge suppliers on combining product deliveries and ask for unpacking at their warehouse if applicable

C

Work with companies that repurpose or take in single use pallets to limit the amount of pallets that are thrown into waste and promote upcycling

C

Potential savings:
- Less waste
- Some companies pay a small fee for every pallet they take in, so it is even a way to make a little bit of money

Investment costs:
- None

Barriers:
- Extra labour for communication and pick up

2030

Phase in local or reusable alternatives for products usually supplied on single pallets, such as furtiniture & decor

C

Potential savings:
- Lower furniture costs for tenants
- Lower packaging waste costs

Investment costs:
- High initial investment

Barriers:
- Branding
- Tender competition

Initiate modular furniture for the decor of stores, that comes from local or upcycled sources so the CO2 footprint from the source is low and so that it can be reused for new stores in the future.

2040

Eliminate all suppliers from outside the EU and have a fully locally sourced airport. Only work with the EPAL system.

2050 vision

Zero single use pallets.

Cardboard

70 000 kg of waste come from milk cartons that are thrown away at Oslo Alrport yearly.

The CO2 footprint of this is around 85974 Kg/CO2/Year.

Overarching interventions (immediate start)

- Stimulate bulk buying and work with suppliers to make this possible for commercials
- Education about the benefits and importance of reducing packaging waste
- Work with suppliers to supply in gitterboxes, reusable crates or other circular solutions
- Challenge suppliers on combining product deliveries and ask for unpacking at their warehouse if applicable

2030

Pressure and collaborate with suppliers and provide incentive to replace cardboard packaging with circular alternatives such as reusable crates

C

Potential savings:

- Less waste
- When the amount of rotations becomes high enough the investment in reusable alternatives might make it more financially beneficial than singe use

Investment costs:

- High intial investment in the circular packaging alternative for suppliers

Barriers:

- Potential extra labour for communication and pick up
- Does not always leads to less CO2 esmissions

2040

Work with smart packaging solutions to limit excessive use of cardboard by personalizing the size of boxes for deliveries

C

Potential savings:

- Less waste
- Less cardboard used & lower CO2 footprint

Investment costs:

- High technology investment

Barriers:

- Costs & limits standardizing

Source all products locally, nothing from outside of the EU preference for products from Norway

Barriers:

- Lack of capacity to supply the needed amounts by local suppliers, thus needing to use multiple suppliers, which is inefficient
- Variability (not everything is availible all year around)

2050 vision

No more B2B packaging waste coming from cardboard. Cardboard packaging is replaced by reusable alternatives.

Plastic foil

14721 kg of waste comes from plastic foil yearly at Oslo Airport.

The CO2 footprint of this is around 31967 Kg/CO2/Year.

Overarching interventions (immediate start)

- Stimulate bulk buying and work with suppliers to make this possible for commercials
- Education about the benefits and importance of reducing packaging waste
- Work with suppliers to supply in gitterboxes, reusable crates or other circular solutions
- Challenge suppliers on combining product deliveries and ask for unpacking at their warehouse if applicable

Introduce biodegradable or compostable alternatives to plastic foil

C

Potential savings:
- Lower ecocosts

Investment costs:
- Alternative can cost more per m2

Barriers:
- Concerns about durability & fulfillment of purpose

Challenge suppliers to use less thick and less meters of packaging foil

C

Potential savings:
- Less waste
- Less use of packaging foil, means lower costs, one roll lasts longer

Investment costs:
- No extra costs

Barriers:
- concerns about durability & fulfillment of purpose

2030

2040

Barriers:
- Lack of capacity to supply the needed amounts by local suppliers, thus needing to use multiple suppliers, which is inefficient
- Variability (not everything is availible all year around)

Source all products locally, nothing from outside of the EU and strong preference for products from Norway

Implement circular alternatives to plastic foil

C

Potential savings:
- Potential lower ecocosts (over small distances)
- Over enough rotations product costs per use can become lower than singe use alteranative

Investment costs:
- High initial purchase costs

Barriers:
- Currently not lightweigt
- Ease of handling

2050 vision

Zero plastic foil waste.

Secondary packaging

There is an unknown amount of secondary packaging being thrown away as waste, even though the product is already packaged with primary packaging. This secondary packaging has the primary goal of increasing ease of transportation. However, it is currently not CO2 emission friendly to replace it with a circular alternative due to high weight or high costs.

Overarching interventions (immediate start)

- Stimulate bulk buying and work with suppliers to make this possible for commercials
- Education about the benefits and importance of reducing packaging waste
- Work with suppliers to supply in gitterboxes, reusable crates or other circular solutions
- Challenge suppliers on combining product deliveries and ask for unpacking at their warehouse if applicable

2030

Eliminate the sales of single use water bottles and install water tapping points

W C

Potential savings:
- Less packaging and bottles in waste

Investment costs:
- Water tapping points

Barriers:
- Water bottles are a source of income, intervention results in less profit

Rethink products - Eliminate the sales of prepackaged sodas and eliminate secondary packaging and primary packaging by introducing syrup dispensers for sodas to fill up passengers own bottles

W C

Potential savings:
- Less packaging and bottles in waste
- No more coolers needed for all packaged drinks

Investment costs:
- Syrup dispensers/ machines

Barriers:
- More manpower needed
- Hygiene
- Elimination of a profitable product, leading to less profits

2040

Source all products locally, nothing from outside of the EU preference for products from Norway

Barriers:
- Lack of capacity to supply the needed amounts by local suppliers, thus needing to use multiple suppliers, which is inefficient
- Variability (not everything is availible all year around)

2050 vision

Eliminate all waste from secondary packaging by integrating circular solutions to transport products.

Reuse area

Currently, there is a lack of signage, there are no set routes in the warehouse and there is no space or it has not been identified for new refillable/reusable packaging solutions.

Introduce new wayfinding signs on the ground, clear signage at the entrance of the waste station & above return items

W C

Potential savings:
- Less incorrecly sorted reusable packaging waste, so they can be in the system longer

Investment costs:
- initial investmment in the signs

Barriers
- Costs

2030

Utilize vertical storage solutions to make use of the height of the space for internal items

W C

Potential savings:
- More space for reuse solutions

Investment costs:
- High investment in warehouse racks

Barriers:
- Inefficient if suppliers do not have their own forklifts

Introduce digital signs and extra RFID systems for tracking of return items

C

Potential savings:
- less incorrectly sorted reusable packaging waste
- Enables personalization

Investment costs:
- High investment costs for signs

Barriers:
- Costs

2040

Warehouse optimization by automation and robotics

C

Potential savings:
- Elimination of human errors leading to more time efficiency, less labour costs and no incorrect sorting

Investment costs:
- High investment in automation & robotics

Barriers:
- Costs

2050 vision

Designated areas for return items are easily detacable leading to no waste due to incorrect sorting and the capacity for return items is enough to cover all incoming new circular solutions.

Communication

Currently, communication between different stakeholders is not on the agenda. This communication is needed to make a change in the amount of packaging waste produced. This change has to come from every stakeholder, however, there are certain things Avinor can do to accelerate and simplify this transition.

Regular meetups and workshops that are topic specific on packaging

Assign a packaging representative from Avinor and from every tenant and supplier that is responsible for keeping up to date with current requirements and developments and communicating these developments

2030

Introduce yearly packaging awareness week

Establish an online app or platform for different stakeholders to help ease communication

2040

Define shared KPIs for future packaging waste goals with stakeholders along the supply chain

Establish collaboration as a core value for Avinor, tenants and suppliers

Overarching

Potential savings:

- Collaboration is essential for every part of the roadmap and for succesful implementation of circular solutions, potentially reducing costs, ecocosts and definitly reducing waste

Investment costs:

- Event costs and platform development costs
- Labour costs

Barriers:

- Time intensive
- Potentially extra staff needed, higher costs

2050 vision

Clear communication between all stakeholders and regular meetings. There is collaboration along the supply chain to work on reducing packaging.

Other interventions

There are also other interventions that could lead to less packaging waste in less researched areas, such as cleaning products (less researched due to the scoping of the project). These interventions are also important to mention to inspire.

Force suppliers to put return or reuse information on the packaging solution

C

Potential savings:
- Higher effeciency & less incorrect sorting

Investment costs:
- No clear plan yet on how to put this on the items and the costs, so this has to be developed

Barriers
- None identfied

Introduce a centralized cleaning supply with sustainable powder/syrup refillable cleaning products

W C

Potential savings:
- Less packaging waste

Investment costs:
- Low investment, as cleaning supplies have to be bought either way

Barriers:
- Effecitvity has to be assured

2030

Use digital tag technology on all return/reuse items to gain trust in the system and use the data on feedback and optimization

C

Potential savings:
- More trust in reuse solutions

Investment costs:
- High investment in tracking and data analyzation

Barriers:
- High costs

Potential savings:
- Less waste
- More collaboration
- By reusing, less new things have to be bought

Investment costs:
- Platform development

Barriers
- Incentive to work with this has to be clear

Set up a too good to go platform for packaging

W C

2040

2050

Contribution

To conclude I will discuss the added value of the project for Avinor and TULIPS.

This project aimed to research which packaging could be reduced without compromising the integrity and quality of goods and to look at where the introduction of reusable packaging would result in the greatest waste reduction. Furthermore, it was part of the assignment to look at areas in which refill stations would be applicable, what circular solutions are already in place, and what goods come with the most packaging. These questions have been answered in this report. It was shown that decreasing packaging waste is complex since it is a logistical challenge to communicate with the different parties along the supply chain from which Avinors' tenants import goods. Furthermore, the most important factor for packaging choices is low cost and functionality, which is currently fulfilled best by single-use packaging in many cases. Suppliers are also trying to tackle the same issues as Avinor. Due to upcoming EU regulations and government incentives to reduce packaging, it is becoming a hot topic for every stakeholder. However, due to increasing costs or compromising the quality of goods introducing reusable packaging is often not done yet.

This research provides Avinor with an overview of the current situation and challenges they are facing regarding packaging sustainability. It gives an overview of different barriers that have to be overcome to introduce more reusable packaging and provides them with a plan to move towards a packaging waste-free 2050. This future vision aligns with the goals of the TULIPS project.

The roadmap also supplies different design interventions that can be implemented to get to this sustainable future within the context of Oslo Airport.

The concept is also a way to minimize waste in an area Avinor can directly influence without the need to collaborate with other partners. By optimizing their warehouse they can minimize wrong sorting and provide the possibility to grow the amount of circular packaging solutions that can be stored in their warehouse, enabling future development. Furthermore providing warehouse workers with more strict and sticking wayfinding shows the importance of correctly sorting their items and improving efficiency and flow. This is beneficial for the workers since one of the challenges in warehouse workers' jobs is the time pressure they face.

The project is also part of the TULIPS project and it contributes to the knowledge on where and how we can implement circular packaging alternatives in the context of an airport. This report can be used as an inspiration and adapted to fit different contexts through context-specific research. The overarching message that communication, collaboration, and local sourcing are essential for the packaging industry can be applied to all contexts.

In the last phases of this project, the application of this graduation project was discussed with Avinor. It was mentioned that the concept for the waste station would be an improvement, but deciding about implementing this is up to another department. Moreover, powdered oat milk, which is one of the interventions on the roadmap, might be introduced to tenants.

Overall the concept and roadmap are established to help Avinor achieve a packaging waste-free future. Still, there are more ways to achieve this than only the ones in the report. However, this report highlights important problem areas and aspects to consider and provides design interventions to achieve the packaging waste-free goal for 2050 of Avinor.

Recommendations

In this chapter, the recommendations related to the roadmap implementation and concept are stated.

Progress meetings

For the roadmap and concept to be implemented successfully regular progress meetings and meetings with different stakeholders are needed. This is also elaborated in the communication section of the roadmap but is of the utmost importance to make a difference in the packaging waste produced at Oslo airport, thus why it is emphasized here once more. Communication and collaboration are key and therefore it is recommended to have regular meetings.

Employee training

For different interventions in the roadmap employee training is needed. This needs to be done to create awareness of the importance of the proposed interventions and since the interventions will alter the day-to-day operations they have to perform during their job. This holds for tenants, but also for suppliers, who are not under Avinor's control.

Testing

The concept and interventions should be iterated for a longer time and at the location before making large investment costs.

Packaging industry monitoring

It is recommended to assign someone at Avinor to become responsible for monitoring the developments in the packaging industry and communicate this to other stakeholders.

Moreover, it is recommended to ask the tenants to also assign someone in their company as a packaging representative as well, if they do not have this yet. This way it is clear who to reach out to in case of questions or with recommendations.

These people are then together responsible and have to collaborate on finding solutions to reach their packaging waste goals and help with others' challenges. By putting these representatives together in an accessible platform, or a business WhatsApp or teams group, communication is easier to establish, and one of the barriers to integrating circular solutions, lack of communication, is lifted.

Further research for concept development

Due to limited time and visits, there is still a need for further research in the return area of RP19. The exact peak storage capacity and the amount of items there are in the reuse area at peak times is unknown. Therefore it was difficult to make an exact estimation of how much space is needed to store the return items and how much space is left. The number of return items in the concept was now based on the various visits to the waste stations, but there has never been a possibility to monitor this more in-depth during a longer period, eg. one week. This is recommended to do if the concept is implemented.

Limitations

In this chapter the limitations of this project are stated

This project has given insights into how and where circular packaging solutions can be implemented and what the problem areas are at Oslo Airport. However, there are also limitations to the project.

Time limitations

Due to the thesis being restricted to 100 days of working time the detailing of the project is limited. It would take further research to see how implementable the interventions on the roadmap are. It would be useful to research the willingness of tenants to implement certain solutions. Furthermore, it was also difficult to establish contact with all needed partners on the supply chains of products. It would help to have more meetings without time constraints with suppliers, such as supplier 3, supplier 2, and supplier 1 to discuss the implementation of more circular solutions further and it would make sense to map them in more detail. This way it can be possible to monitor where the barriers to implementation are and when they can be overcome as each stakeholder has different values.

For the concept, it would be recommended to take more time to test out signage in person and see when exact dimensions of boards and text are needed and if the concept results in less packaging waste. As the literature notes, in-person testing is one of the most important aspects of designing an efficient warehouse.

Research limitations

Firstly since the context of the project was in another country there was limited access to the context of the project. This meant that there were limited opportunities to talk to the stakeholders and visit key locations such as the waste station.

During the interviews and conversations at the airport one of the limitations was the limited knowledge of English of Employees at Oslo Airport. Especially the older generation had problems phrasing their comments in English. This led the participants to be visibly reserved during interviews and collaborative sessions.

Another limitation of the research on location was that the airport was a busy environment. This caused interviewees to have to divide their attention between the interview/conversation and work at busy times, leading to unstructured answers and having to break up conversations multiple times.

Generalizability

The project is carried out in collaboration with TULIPS and an interesting application of the project would be to make the roadmap applicable to more airports. However, since the project was carried out within the context of Oslo Airport the application of the roadmap and concept to different airports is limited. To apply this project to different airports more research would be needed.

Personal reflection

This chapter presents a personal reflection

To conclude my project, I would like to reflect on this project from a more personal perspective. At the beginning of this project, I had set different goals for myself.

The main goal revolved around project management and the different aspects of taking on such a big project. I had worked in a bigger company before and noticed that clear and understandable communication is one of the most important aspects of working with many stakeholders. In this area, it is also important to keep developing yourself.

Over the course of this project, the importance of communication with different parties was emphasized multiple times, and I sometimes made mistakes of not communicating clearly or often enough. However, I corrected myself and tried to be assertive in communication and planning. This was done through meetings and weekly emails. Overall this whole project was difficult, but I did it to the best of my capabilities and learned and developed myself further. And one of the fields I did that in was as a communicator.

Another field I developed in was as an academic designer. I had to use literature and other research methods to develop my concept. Moreover, I had to write this extensive report, which was a whole challenge in itself, as structuring your process and thoughts on paper when you are so deep into a project is always a challenge. These things taught me to be disciplined and to use my time wisely.

It also thaught me the importance of immediately reporting on what I had done during the day after I did it, as I would otherwise forget it and struggle afterward. This was not always perfect, but I developed myself more and more in this during the project. Such a project as this one makes you aware of where your strengths and weaknesses are. I found that I am good at thinking, but that I have difficulty making final decisions and am sometimes too much of a perfectionist, which hinders me in the efficiency of my projects.

I also tried to challenge myself at the end by visualizing my concept in a way that was new to me. Due to the outcome of my project being different than I had imagined it to be, I was overall less satisfied with my concept direction. As signage and layout were not something I was initially very excited about. However, by taking inspiration from one of my friends I decided to take the time to visualize my concept in VR. Which brought me joy and excitement. It was also a way to meet new people, which motivated me to work during the summer vacation and develop other skills that I had not developed as a SPD student before.

As described I encountered different challenges, but the challenges were sometimes also more personal. The most personal one was the loneliness that developed during my project. Graduation is something you do by yourself, which means countless hours of sitting behind a desk alone. I have never been the best at personal projects, as I like to work in groups. Other people inspire me and make me the best version of myself, as I thrive under a healthy bit of competition and like being challenged by others. Moreover, the feeling of being alone also grew from the combination of this project and my concussion. As studying was the only thing I could do, I did not see many people during the week. This was one of the challenges that came across my path. Having Maria and Thomas was therefore important and this helped me, but still, I had never had this before and was mentally struggling with this. Due to this, I felt incapable sometimes because I could not do everything I wanted to do, as a student, family member, or as a friend. After my concussion faded, I overcompensated and wanted to see everyone important to me again. Finding the balance back between studying and my personal life was hard. In the end, I think everything worked out, and I overcame this more personal struggle.

It was a pleasure and a unique experience to work on such a big project. The company, Avinor, and its employees were kind, inspirational, and helpful. This graduation project was a unique way to challenge myself and get to experience what working on sustainability in the field of mobility and packaging is like. It was also enriching to see my fellow students work on different topics in the same context and to get to experience Oslo and its culture. A last thank you for everyone involved.

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Appendix

Appendix A: Interview transcripts & notes
Appendix B: Co-creation session
Appendix C: Observation grids
Appendix D: Excel tenant visits
Appendix E: Eco assessment
Appendix F: Influence model
Appendix G: Ideation notes & sketches
Appendix H: Testing
Appendix I: Overview of operators and commercial units
Appendix J: Concept

Appendix A: Interview transcripts & notes

- Interview KIDV notes
- Interview Supplier 1 transcript
- Interview Supplier 2 transcript
- Interview Supplier 3 transcript
- Interviews Waste Station transcript
- Interview F&B operator 1 transcript
- Interview F&B Operator 2 transcript

KIDV interview setup & Notes:

Questions & goal:

Goal: Uncover how to approach a project like this, how to start and to what extent we have an influence on packaging decisions. As he has had many projects like this one before it is interesting to know how this is done.

Questions drafted beforehand:

-Wat zou jij uit ervaring aanraden om als eerst te doen als je met zon project start?
-Ik zie heel veel voorbeelden van ciruculaire vervangingen, maar het probleem, zoals ik het nu zie, is dat het veel ligt bij bedrijven/suppliers laten smaenwerken en het laten gebruiken. Hoe krijg ik dit voor elkaar?
-Hoe pakt u zon groot project aan als “buitenstaander”? Gelijk alle mensen benaderen of eerst zelf nadenken en met een oplossing komen?

Interview notes

Time & Date: 13/3/2024, 16:00
Duration: 1.25 hours
Location: KIDV, The Hague

To get more insights into the packaging industry, I talked to an employee of the KIDV, who has worked in the packaging industry ever since he started working after his studies.

He mentioned that the packaging world is very complex, as I had found out already, but also that it is very hard to make a difference in long supply chains. The longer supply chains make it almost impossible to have an influence, especially if you are not integrated into that company itself. Starting a movement is almost impossible as there is no demand for it currently. The costs are high and packaging has to fulfill its job of protecting goods but also has to be cheap. The way he would approach that would be mainly through policies. This applies to Avinor since they can use the new contracts they supply tenants with.

Another insight was that with the new PPWR regulations in mind, it is very useful to set goals in the long term and make policy alterations because it requires companies to change parts of their operations. The smaller the supply chain, the easier it is to have an impact on packaging choices as a company such as Avinor. When collaborating with each other throughout the supply chain or a hub such as an Airport, we can learn from each other and reuse each other's packaging to establish a more circular environment.

Currently, we are more into recycling, but the recyclate is not used, since it is expensive and hard to use. With food, it is not allowed in many cases.

Many reuse items are only useful in short supply chains, but the EU regulation can make companies work together more, making it more applicable, but that has to happen first.

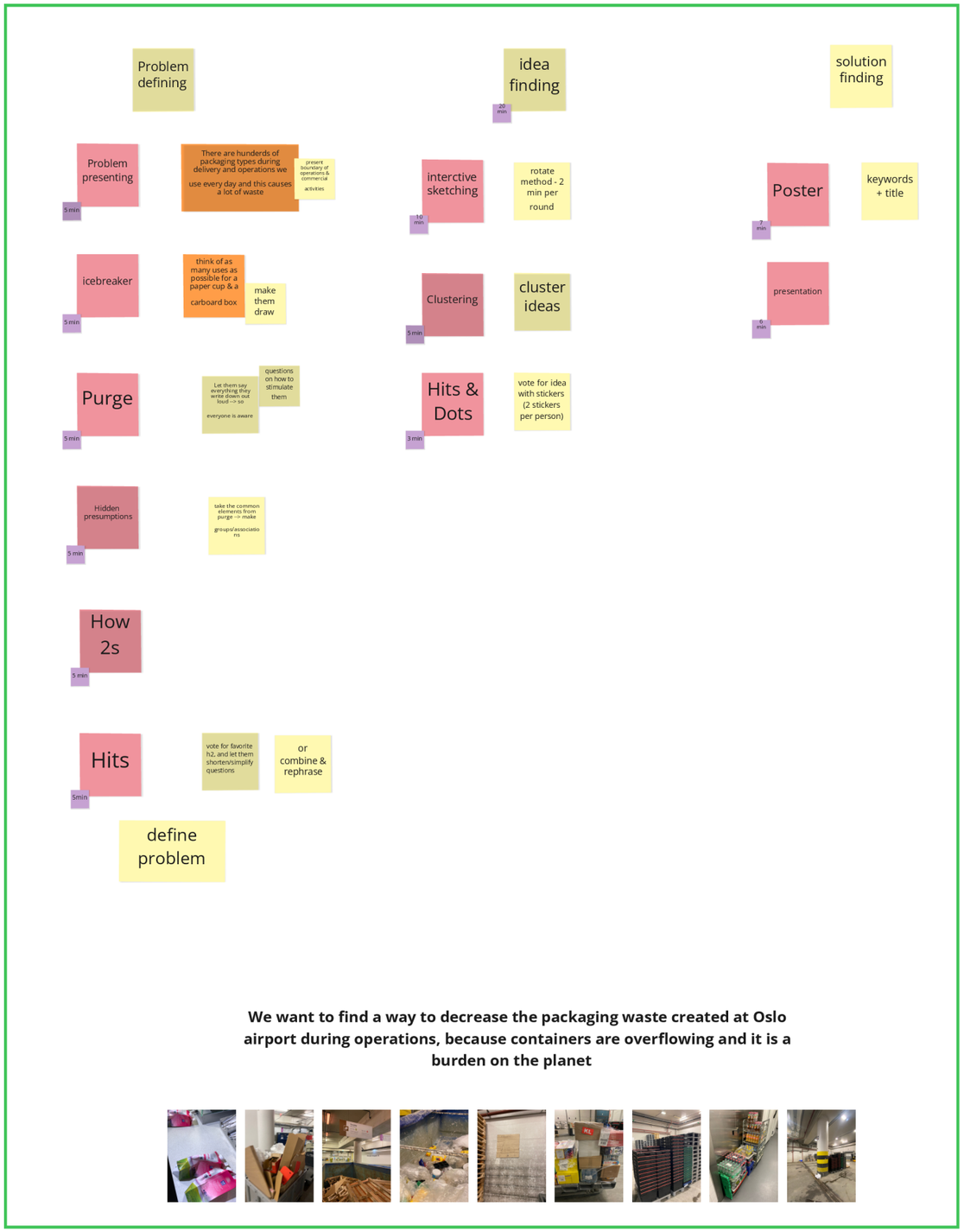
Tips to tackle the assignment:

- Give existing examples
- Look at what is already in place and what not
- Map the barriers
- Collective approach
- Locality
- Inspire with a green team
- Reduce the transport of air
- Challenge suppliers to use less

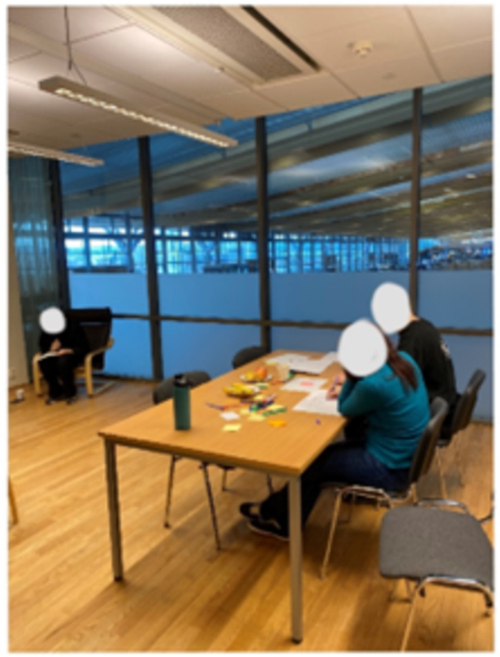
Transcripts: SEE CONFIDENTIAL APPENDIX

Appendix B: co-creation session

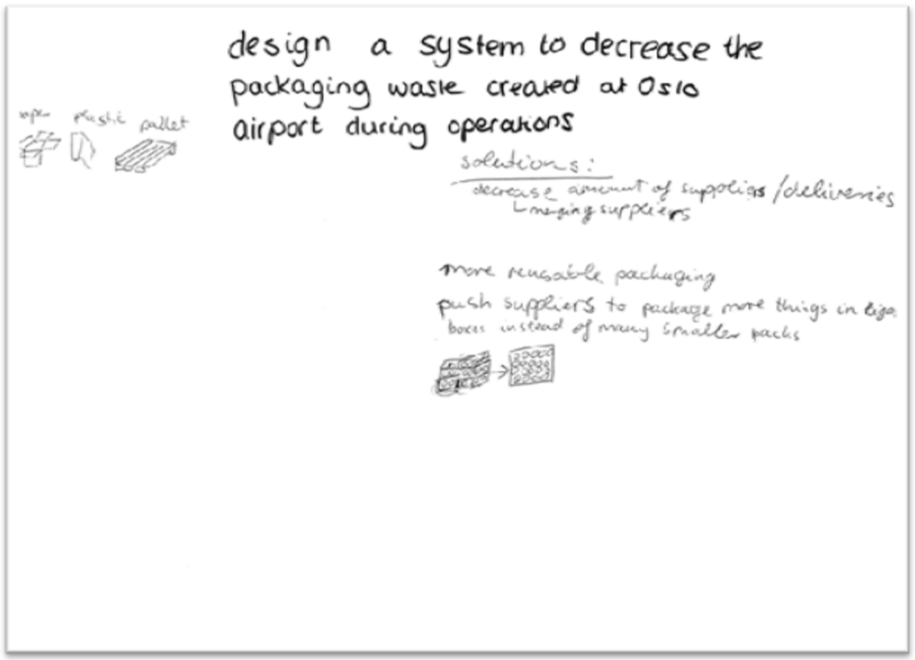
Co creation plan

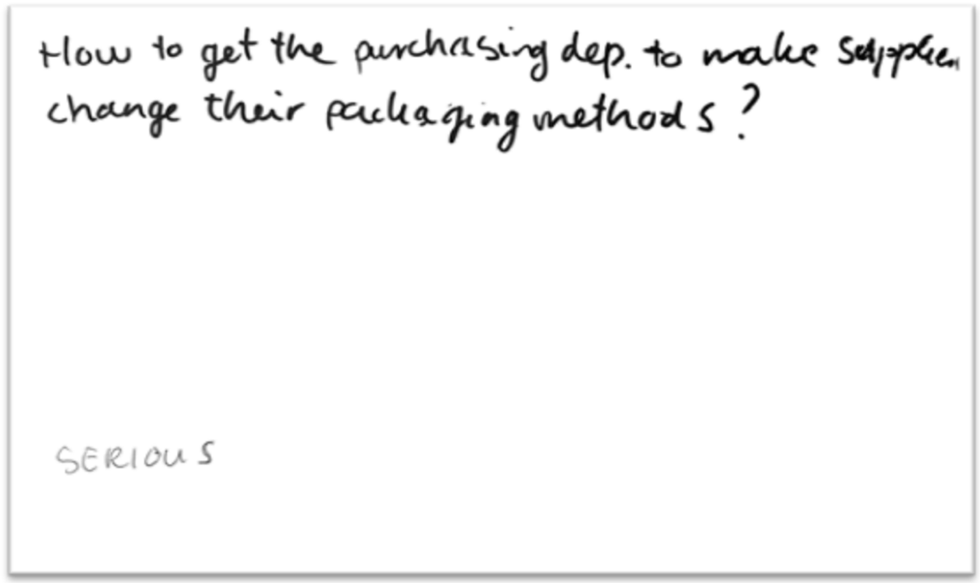


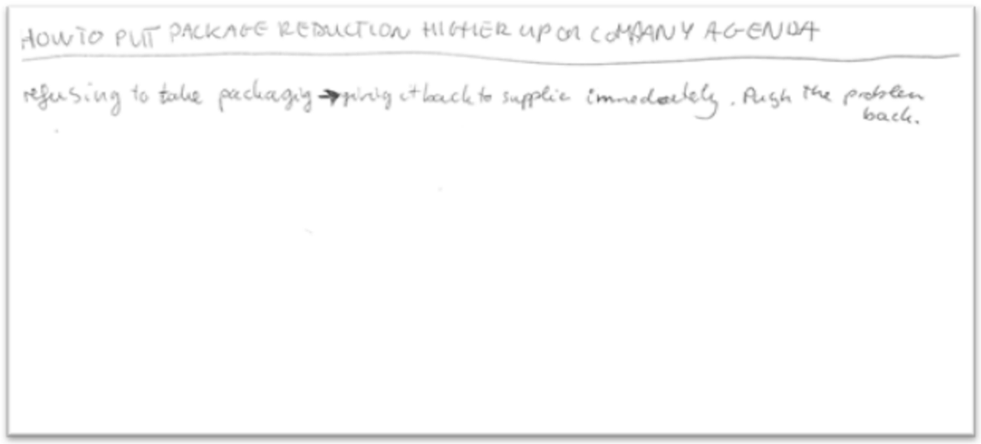
Co creation set up

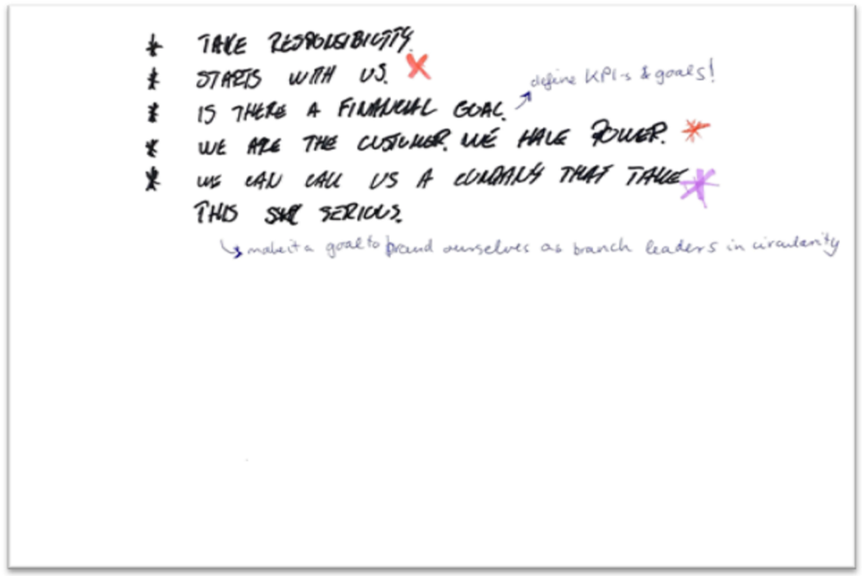


Results









DESIGN

INNKJØP ppl

BRANDIMAGE

SUPPLIERS

How to:

- get the purchasing dep. to be on board?
- get more supplier to merge with each other?
- make suppliers to package in bigger portions / crate
  - use reusable packaging
- eliminate small packaging
- achieve synergy between companies

- Put package reduction higher upon the [illegible] agenda – MUD TO OUR SUPPLIERS.
- Empower the "Innkjøp" ppl with knowledge about circularity
- Make detailed roadmap for packaging-free procurement with measurable goals
- Follow up the above mentioned ideas

make parties and gigs to promote the issue

- have a dedicated re-use packaging area pimped up with design Make it cool!

daylight!

KEYWORDS

Suppliers ← pushing! → bigger portions
ex: wine in to, chop

purchasing department (procurement)

decisions internally

§ regulations

synergy

Appendix C: Observation grids

SEE CONFIDENTIAL APPENDIX

Appendix D: Excel tenant visits

SEE CONFIDENTIAL APPENDIX

Appendix E: Eco assesment

Materials + CO2 footprint													
Waste stream	Material	Weight waste	Amount	Amount	Amount	CO2 footprint	CO2 footprint	CO2 footprint	Range CO2 footprint (pallets)	CO2 footprint	Actual footprint	Source	
UNIT		kg	units	m2	liter	Co2eq/kg	per unit	per m2	(Deviatkin et al., 2019)	1000 liter packaging	Co2eq per year		
Plastic foil	LDPE (closed loop recycling)	14721		319674,2671				0,1			31967,43	Idemat light LCA app	density LDPE = 921 kg/m2, foil tickness 50 mu
Wooden pallet (EPAL size) (25 kg)	Pine wood	183775	7351				4,12		-26 to 9.9 kg CO2-eq per pallet		30286,12	ARTICLE 1 (Vásquez et al., 2022)	
		183775	7351				0,34				2499,34	ARTICLE 2 (Deviatkin & Horttanainen, 2020)	
Plastic Pallet (reusable) (20kg)	Plastic						38,85		22-166 kg CO2-eq per pallet (virgin plastic) or 3.7 - 4.1 kg CO2-eq (waste plastic)			ARTICLE 1(Vásquez et al., 2022)	
							120					ARTICLE 2 (Deviatkin & Horttanainen, 2020)	
Cardboard box	Corrugated Board box making	661340				0,13					85974,20	Idemat light LCA app	
	Brown paper kraft					0						Idemat light LCA app	
Milk packaging	Beverage carton (standard)	70000	2000000							17,14	34280,00	https://www.tetrapak.com/en-nl/sustainability/measuring-and-reporting/life-cycle-assessment	milk package weight = 35 grammes
	Beverage carton (plant based)	70000	2000000							3,12	6240,00	https://www.tetrapak.com/en-nl/sustainability/measuring-and-reporting/life-cycle-assessment	1 milk package is 1 liter

Assumptions:

Pallets: For wooden and plastic pallets 2 sources were used. (Vásquez et al., 2022) (A1) and (Deviatkin & Horttanainen, 2020) (A2). These articles were chosen as they present a comparion of the pallet types that are also found at Oslo Airport. Both describe the difference in CO2 footprint for a wooden EPAL pallet vs a plastic reusable pallet, but with a different scope and functional unit. A1 is done in Chili and does not take into account the number of trips, but takes the Co2 footprint from cradle to grave. A2 takes into account a number of trips and the study was done in Finland. The number of trips makes a difference since the weight of a plastic pallet is less heavy and therefore it also makes for less CO2 emissions during transport. In A2 the functional unit of 1000 consumer trips with a service life of 20 trips for a wooden pallet and 66 for a plastic pallet were used. For the end of life the wooden pallets are chipped and taken to incineration plants (information supplied by STENA recycling, the waste handler of Oslo Airport), therefore the incineration scenario was chosen. To crosscheck these articles on accuracy, another article of Deviatkin et al., (2019) was used which presents a review of various LCA studies on wooden and plastic pallets with ranges. All values used are found to be inside these ranges if we assume the plastic pallets are not made from waste plastic.

Finally the study done by (Deviatkin & Horttanainen, 2020) was chosen to give a more accurate representation, where the transport costs were taken into account and the site of research being more similar. In this wooden pallets come forwards as the more environmentally friendly choice. However it is important to note that more research is needed to give an accurate representation of the actual CO2 footprint for the pallets used at Oslo Airport. Wooden pallets store CO2, making their ecocosts less high, but they weigh more during transport. Over big distances orif the plastic pallet lifetime is higher, they could be the more beneficial choice. Differences in handling, transportation, the manufacturing process and usage lifecyle to the data used can alter the carbon footprint. Therefore It is needed to make an alysis on all products coming in from different locations to choose the most environmental friendly option.

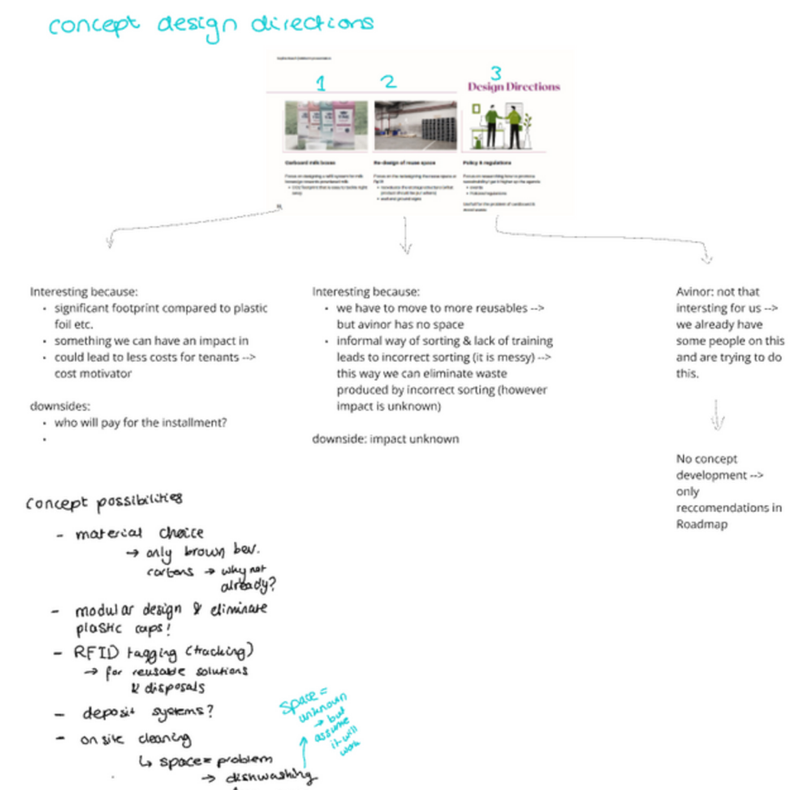
Milk packaging:
Supplier 3 is supplied by Elopak (packaging in Figure B was made by Elopak) for their packaging material and Tetra Pak is another one of the suppliers. One LCA was found for Elopak beverage cartons in North america. However this showed massive differences with a study of Tetra Pak on beverage cartons, where the CO2 emmissions were also shown per country, with specific information for Norway being availibe and the packaging being similar to the cartons used at the airport. Therefore the data of the Tetra Pak was used in this analysis. For more accurate data it is suggested to contact Elopak and gather this information (making contact was tried by emailing them directly, but there was no response). Supplier 3 uses 2 types of beverage cartons. Figure A shows the standard Milk carton, which was used the most at the Airport. Figure B shows their "new" plant based milk carton line, that also does not use the plastic cap at the top of the milk carton. However this type of milk carton was only spotted twice during the visit to Oslo, so it is not taken into account for this analysis. The emissions from the production of the milk are taken out of the equition and this is only the emissions for the packaging. There is no accurate info on the exact percentage of plant based material used in the packaging seen in Figure A. Therefore for the anlaysis the co2 footprint of a standard beverage carton is used.

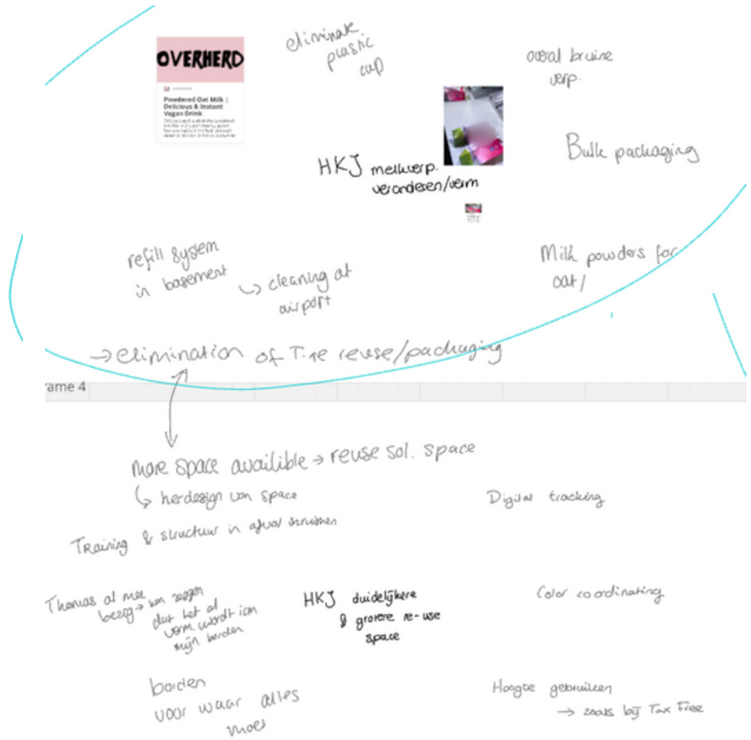
See confidential appendix for the images of the milk packaging

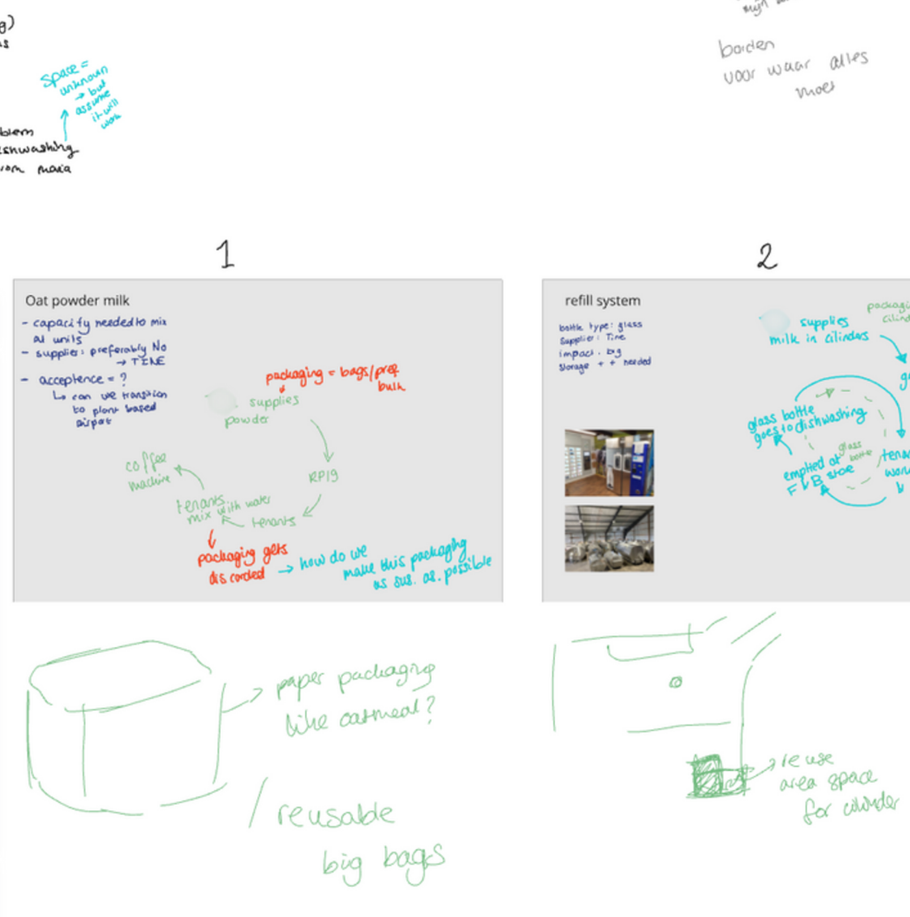
Appendix F: Influence model

SEE CONFIDENTIAL APPENDIX

Appendix F: Ideation







signage

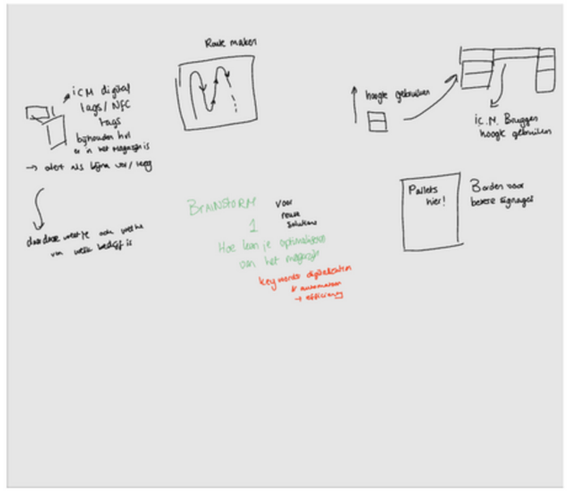
how to optimize

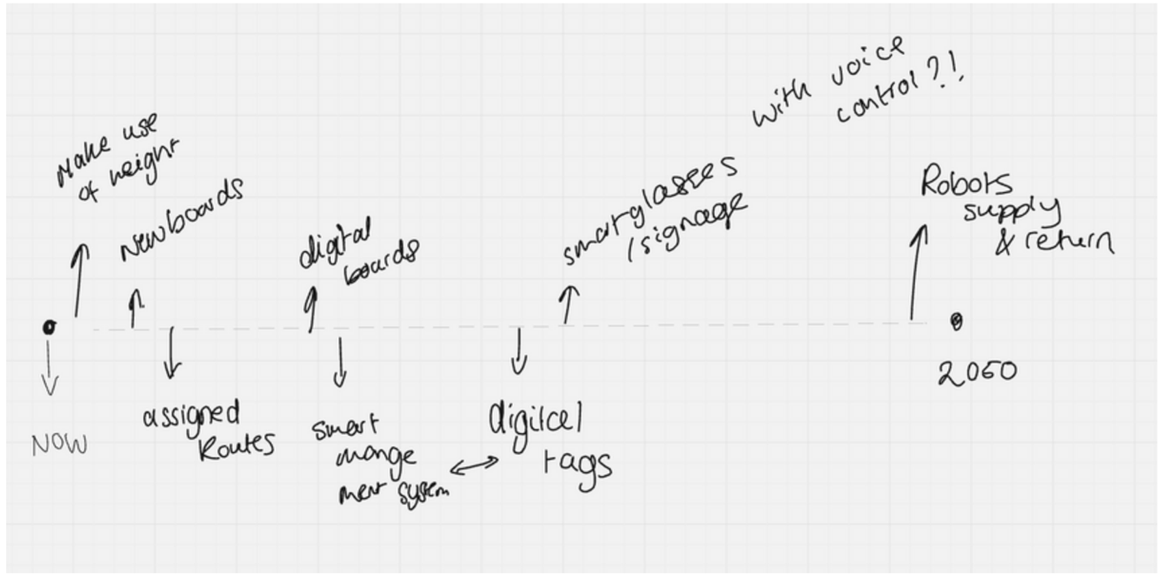
make use of vertical space

how to optimize

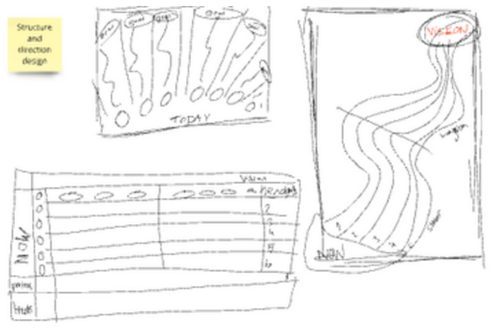
how to optimize

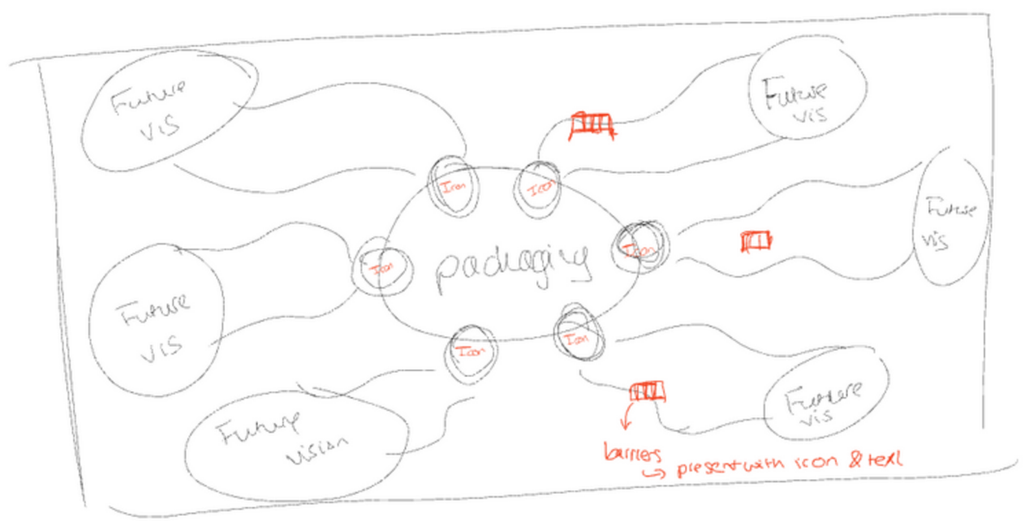
how to optimize

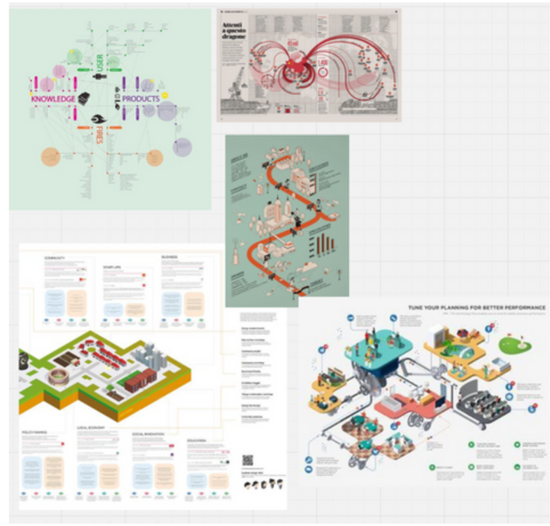




Structure and direction design







Appendix G: Testing

Slides for testing at Oslo Airport during visit 2

Introduction slides

*The circular airport of the future, characterized by freshness, powered by **locality**.*

Enabling employees and travelers to make the most environmentally friendly choices in the most accessible way

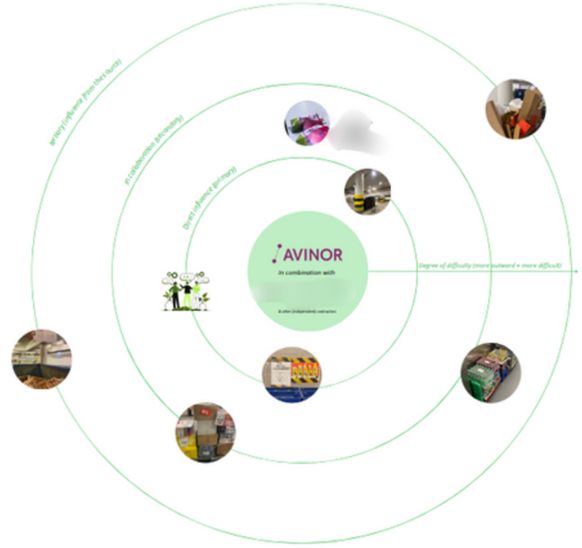
MILK REFILL/OAT POWDER

65.38%*
CO2 FOOTPRINT REDUCTION TOWARDS COW MILK

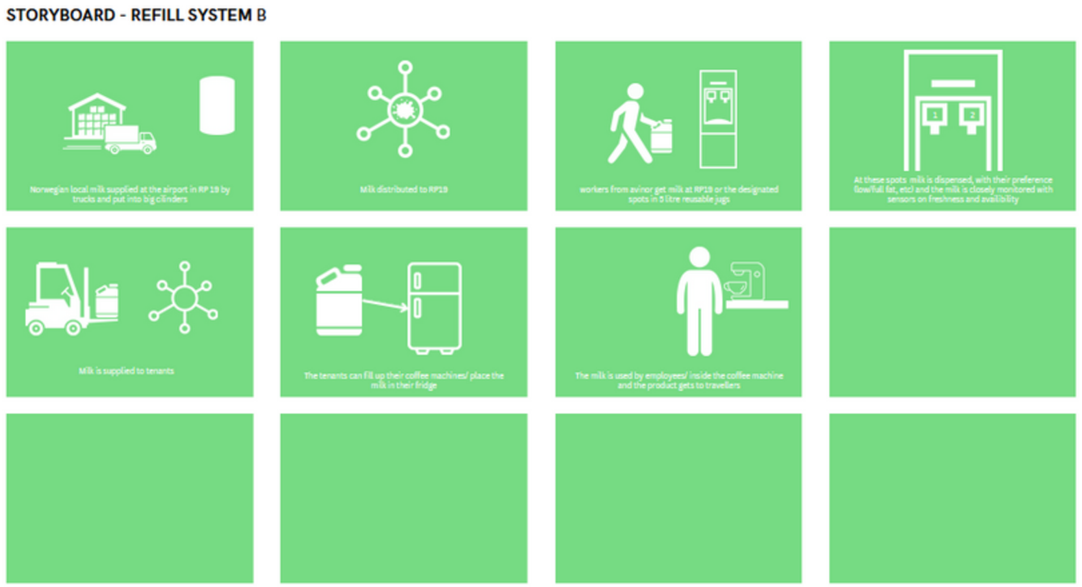
+

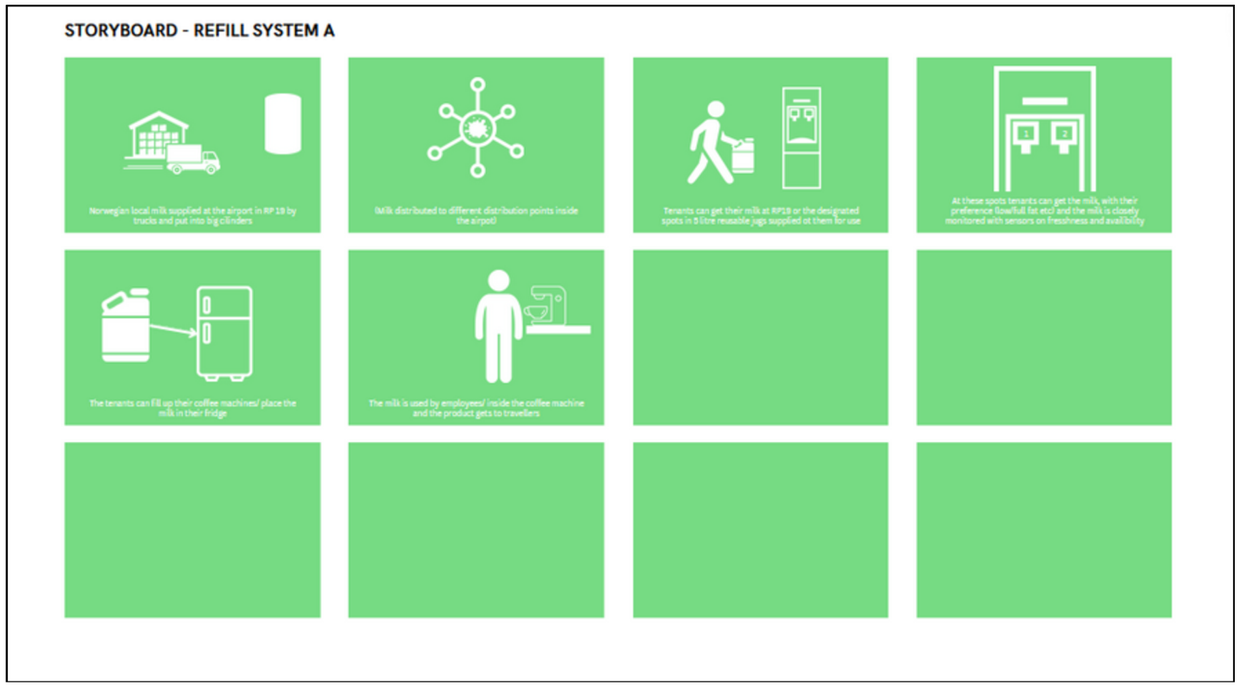
25%
CO2 FOOTPRINT REDUCTION TOWARDS NORMAL OAT MILK

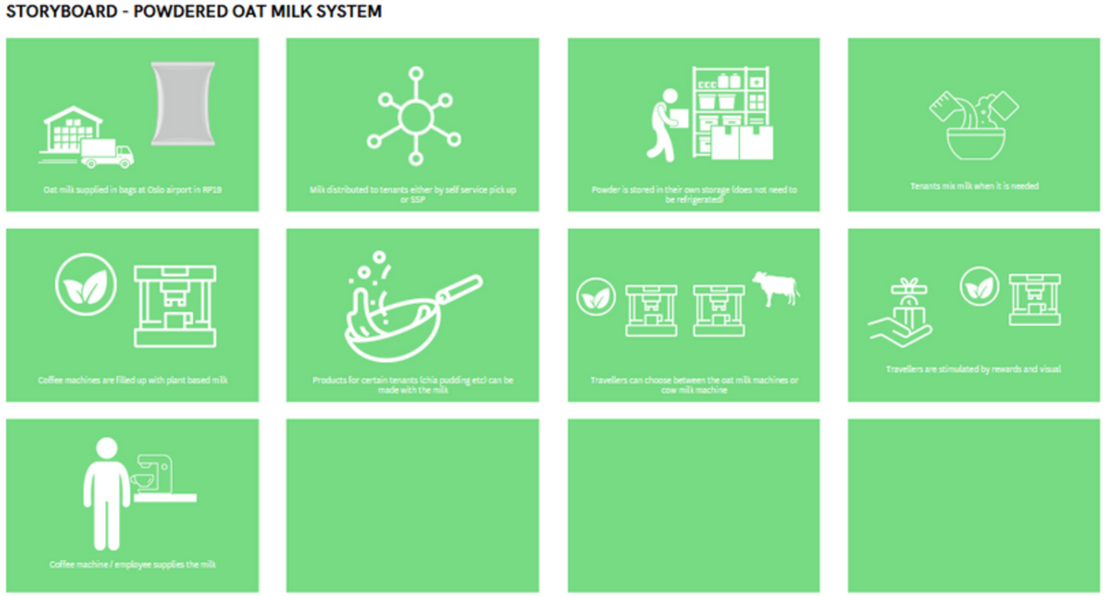
*If the same amount of oat milk is consumed as cows milk now



Slides with scenarios for milk refill & powdered oat milk







Slides with visual probes to discuss interventions with F&B tenant worker

ELIMINATION OF PLASTIC BOTTLES & SYRUPS FOR SODAS

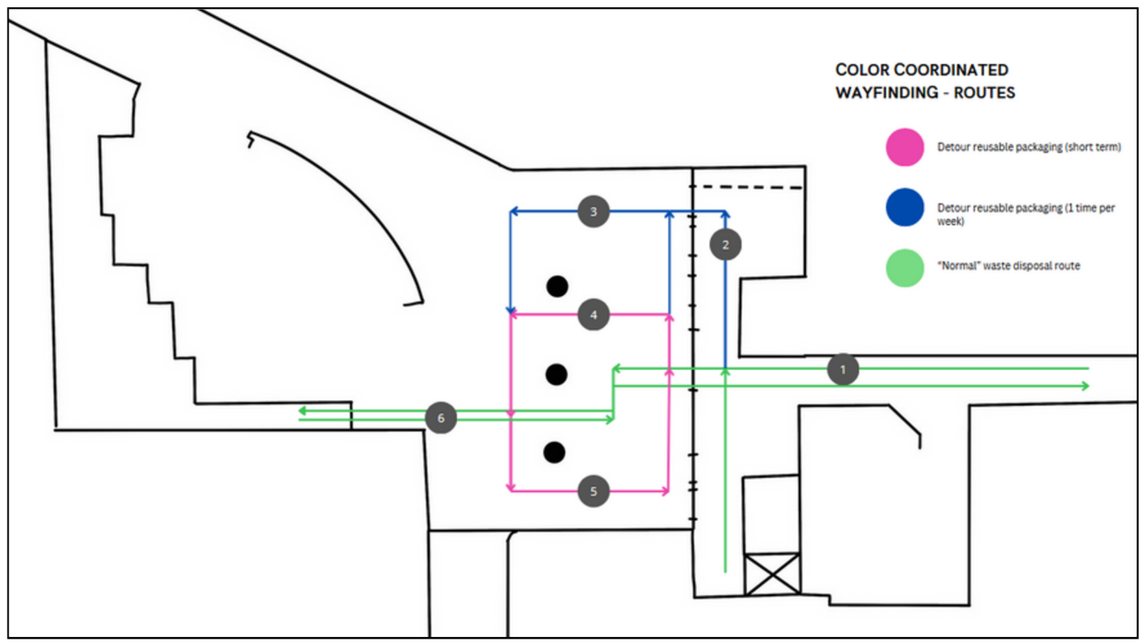
MODULAR INTERIOUR

BULK BUYING OF PRODUCTS

OBLIGATORY VISIT RP19

TOO GOOD TO GO FOR PACKAGING

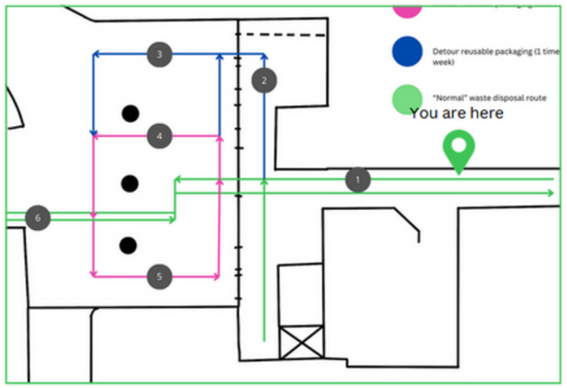
Slides for discussing the concept with warehouse worker, Avinor & supplier environmental representative



Slides for discussing the concept with warehouse worker, Avinor & supplier environmental representative

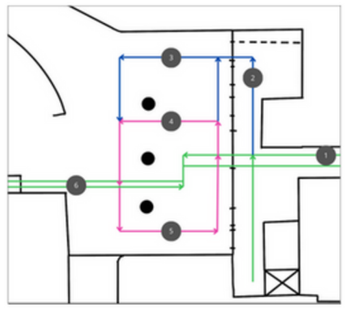
WAREHOUSE WASTE/REUSE ROUTES

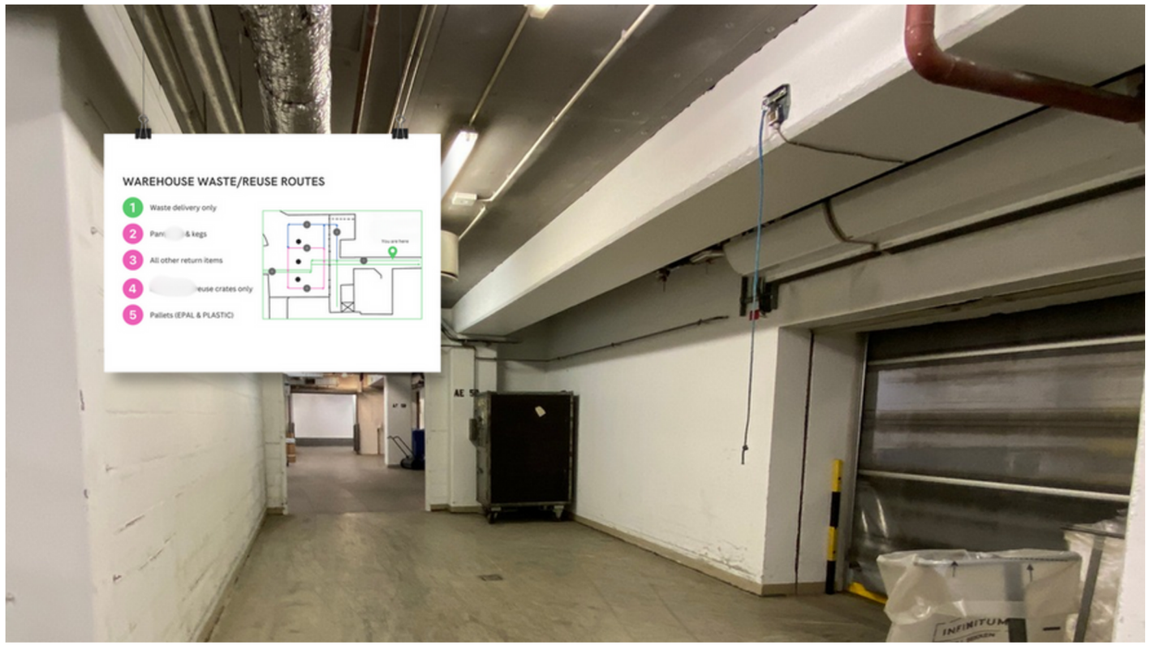
1. Waste delivery only
2. Pant, [illegible] & kegs
3. All other return items
4. [illegible] reuse crates only
5. Pallets (EPAL & PLASTIC)

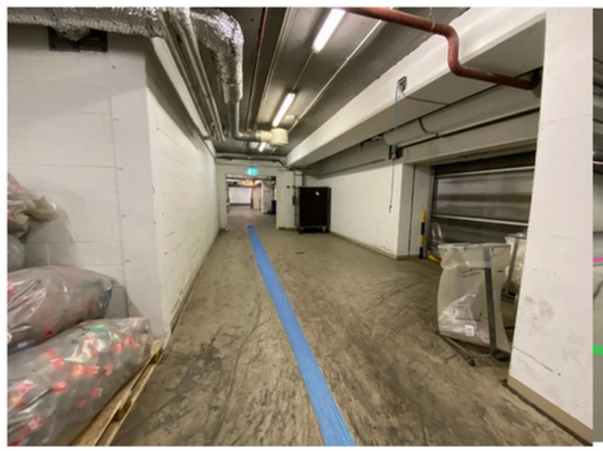


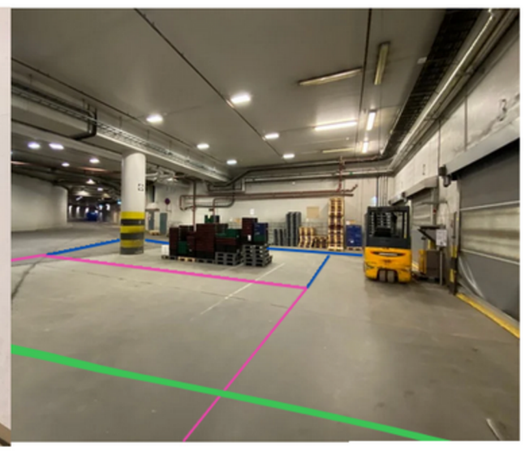
STORYBOARD - RETURNING REUSABLE PACKAGING

1. Entery at waste station, board with assigned routes is displayed
2. Detour reusable packaging (short term) display of return items from supplier 3, cilinders and bottles
3. Weekly pickup packaging area, items for different suppliers
4. Crates for supplier 1 and supplier 2, daily pickup
5. Routes to waste containers, clear by colour coding and symbols
6. Pallet storage area, short term storage



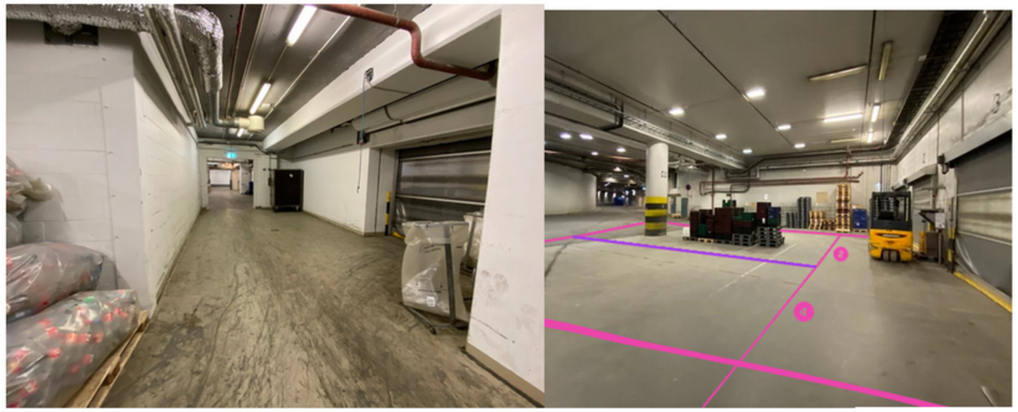






vinyl/rubber signage (durable)

Appendix G: Testing



Testing setup:

goal: Evaluate the concept & roadmap (and ask for preferences on signage, only for Avinor & warehouse worker)
Test participants: F&B operator 1 environmental representative, tenant worker F&B operator 1, Avinor, warehouse worker from F&B operator 1
Test environment: Quiet room in the airport, 1 on 1 setting

Plan:
Intro: Brief the participant on the progress of the project, introduce the roadmap, and explain clearly why it is needed to implement solutions

First start by introducing the roadmap, for the F&B operator environmental representative & Avinor the focus is more on the roadmap. For the tenant worker, the focus is mostly on the interventions on the roadmap that they will encounter. And for the warehouse worker, the focus is on the concept.

Go through all slides, introduce the topic & ask whether they have any remarks and whether they think this would be positive/negative if introduced. Why do they find it useful/why not?

For the concept slides with the different ground signage, ask what is preferred and why (multiple colors/only 1 color)

Round off:

- Ask whether they have any further questions

All transcripts & tables: SEE CONFIDENTIAL APPENDIX

VR concept testing

Slides for testing in NL VR

Testing set up:

goal: Evaluate the effectiveness of the new signage in a VR warehouse environment.
Test participants: 5
Participant profile: Anyone is applicable
Test environment: VR setup and neutral environment in which people have room to move around

Plan:
Intro: Brief the participant on the assignment, introduce to VR equipment and make sure they are comfortable with using the equipment, ask to sign a consent form
Task explanation:

- Show each participant one item from the slides that must be returned to the designated location
- Ask the participants to navigate in the VR warehouse to locate the return location
- Ask them to look at the clues given and ask them to say out loud what they think and use to find their way

Observation:

- Look at the route they take, and what signs they see and use
- Note down what they say while finding their route

Round off:

- Ask participants what they used to find their way, and what they thought of the signs (clear?)
- Ask whether they have any further questions

Participants, times, locations

#	location	Date, time
1.	The Hague	24/7/2024, 20:00-20:30
2.	The Hague	24/7/2024 20:30-20:45
3.	Delft	25/7/2024, 10:30-11:00
4.	Delft	25/7/2024, 12:00-12:25
5.	Rotterdam	25/7/2024, 17:45-18:15

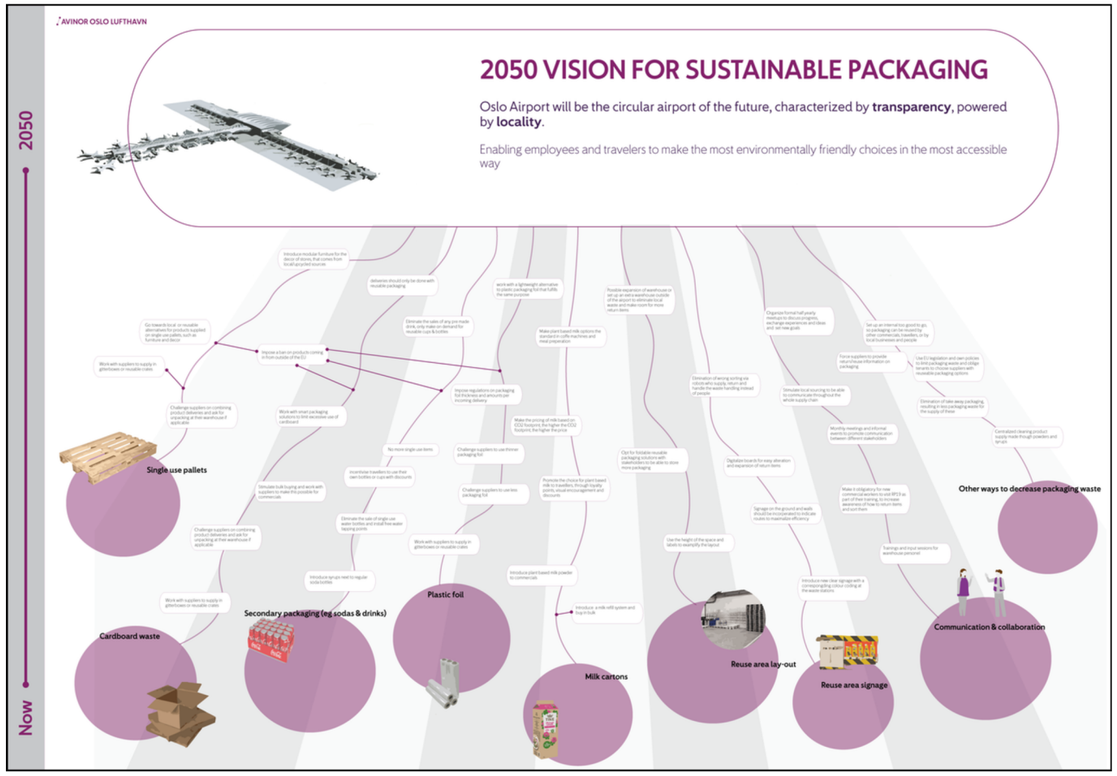
Notes outcomes:

- Participants do not immediately notice the first board --> which might have to be lowered
- Participants look at the lines and logos
- The boards above the items are clear
- Since participants were random people who did not work in the context of the project they were not familiar with the suppliers, the logos on the ground were not helpful for them and made it difficult to find their way since they did not know what supplier the crates belong, it either has to be on the item, or it should be changed to an icon of the item (but the warehouse worker preferred the suppliers)
- The different colors of the lines were useful due to the meanings of these colors being clear when entering the warehouse

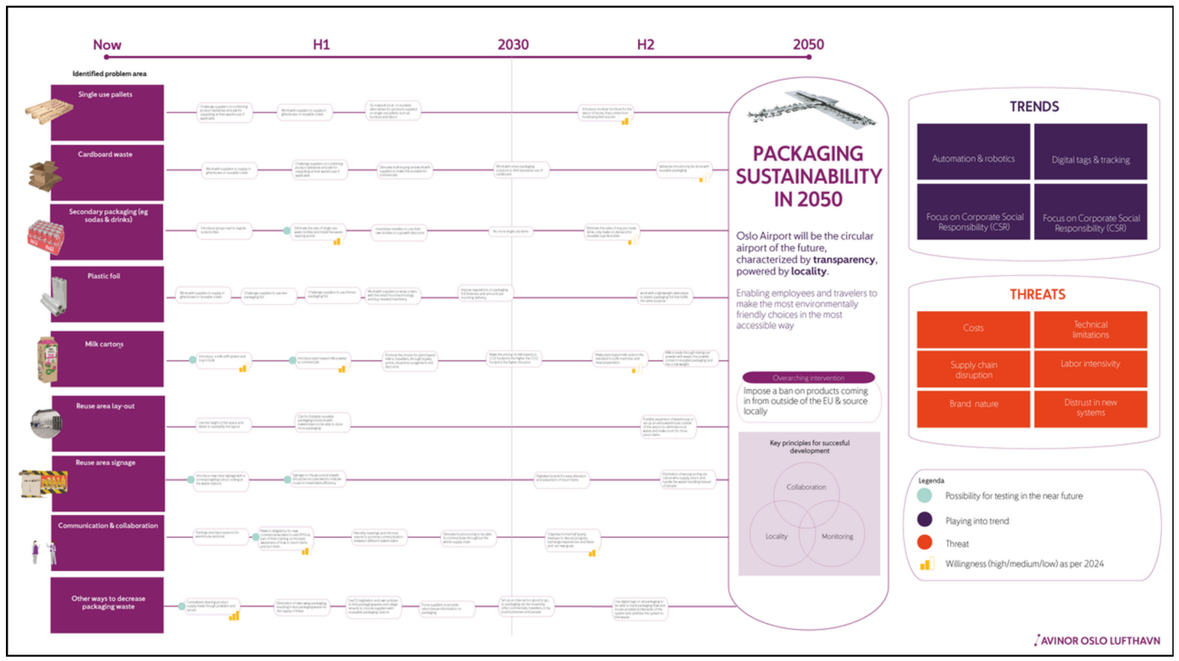
Roadmap testing in NL

Different roadmaps:

1



2



Testing setup:

Goal: Evualte the graphic design flow of the different roadmaps
Test participants: 3
Participant profile: Anyone who has never seen the roadmap in an earlier stage is applicable
Test environment: neutral environment, the roadmaps were shown on a laptop screen

Plan:
Intro: Brief the participant on the assignment, ask them to sign the consent form, and ask them to say out loud what stands out and how they read the roadmap. What is clear and what is unclear?

Observation:

- Note down any comments, ask return questions

Round off:

- Ask participants what they think of the roadmap and whether they have any suggestions for improvements
- Ask whether they have any further questions

Notes:

- Roadmap 1 was followed from the top to the bottom by all participants, it was not clear enough that the roadmap displays the evolution from the bottom up
- Roadmap 2 was clear and understandable to all participants, it was overall preferred
- Icons were clear
- It was unclear how every intervention led to a more sustainable packaging future
- 2 participants mentioned that there was a lot of information on the roadmap, they were a bit overwhelmed when starting the exercise
- Both looked visually appealing to the participants, but roadmap 2 was clearer
- 2 participants mentioned roadmap 1 looked more playful/fun, and thus they found this one more inspiring

First ideas with supervisors:

- the bouncy lines for the way it is not a linear flow are nice, maybe using more metaphors to depict the flow and context can lead to better clarity
- Using “explanation” spreads per problem area can clear some of the overflow of information of the roadmap and lead to better clarity on how different interventions lead to the goal.

Appendix H: overview of operators and commercial units

SEE CONFIDENTIAL APPENDIX FOR THE OVERVIEW

IDE Master Graduation Project

Project team, procedural checks and Personal Project Brief

In this document the agreements made between student and supervisory team about the student's IDE Master Graduation Project are set out. This document may also include involvement of an external client, however does not cover any legal matters student and client (might) agree upon. Next to that, this document facilitates the required procedural checks:

- Student defines the team, what the student is going to do/deliver and how that will come about
- Chair of the supervisory team signs, to formally approve the project's setup / Project brief
- SSC E&SA (Shared Service Centre, Education & Student Affairs) report on the student's registration and study progress
- IDE's Board of Examiners confirms the proposed supervisory team on their eligibility, and whether the student is allowed to start the Graduation Project

STUDENT DATA & MASTER PROGRAMME

Complete all fields and indicate which master(s) you are in

Family name	
Initials	
Given name	Sophie
Student number	

IDE master(s)	IPD ☐ DfI ☐ SPD ✓
2nd non-IDE master	
Individual programme *(date of approval)*	
Medisign	
HPM	

SUPERVISORY TEAM

Fill in he required information of supervisory team members. If applicable, company mentor is added as 2nd mentor

Chair	Sonja van Dam	dept./section	SDE
mentor	Jelle Zijlstra	dept./section	SDE
2nd mentor	Elisabeth Tschavgova		
client:	Avinor		
city:	Oslo	country:	Norway
optional comments	My chair and mentor are from SDE but offer different expertises, Sonja more particular on sustainbility, usability and co-creation and Jelle coaches students on the whole design process. Jelle has worked as an independent designer, while Sonja has a strong academic background.		

! Ensure a heterogeneous team. In case you wish to include team members from the same section, explain why.

! Chair should request the IDE Board of Examiners for approval when a non-IDE mentor is proposed. Include CV and motivation letter.

! 2nd mentor only applies when a client is involved.

APPROVAL OF CHAIR on PROJECT PROPOSAL / PROJECT BRIEF -> to be filled in **by the Chair** of the supervisory team

Sign for approval (Chair)

Sonja van Dam - IO — Digitally signed by Sonja van Dam - IO, Date: 2024.02.12 14:58:01 +01'00'

Name: Sonja van Dam | Date: 12 Feb 2024 | Signature:

CHECK ON STUDY PROGRESS

To be filled in **by SSC E&SA** (Shared Service Centre, Education & Student Affairs), after approval of the project brief by the chair.
The study progress will be checked for a 2nd time just before the green light meeting.

Master electives no. of EC accumulated in total	EC
Of which, taking conditional requirements into account, can be part of the exam programme	EC

★	**YES**	all 1st year master courses passed
	NO	missing 1st year courses

Comments:

Sign for approval (SSC E&SA)

Robin den Braber — Digitaal ondertekend door Robin den Braber, Datum: 2024.02.15 10:52:00 +01'00'

Name: Robin den Braber | Date: 15 feb 2024 | Signature:

APPROVAL OF BOARD OF EXAMINERS IDE on SUPERVISORY TEAM -> to be checked and filled in by IDE's Board of Examiners

Does the composition of the Supervisory Team comply with regulations?

YES	★	Supervisory Team approved
NO		Supervisory Team not approved

Comments:

Based on study progress, students is ....

★	**ALLOWED** to start the graduation project
	NOT allowed to start the graduation project

Comments:

Sign for approval (BoEx)

Monique von Morgen — Digitally signed by Monique von Morgen, Date: 2024.02.20 11:00:20 +01'00'

Name: Monique von Morgen | Date: 20 Feb 2024 | Signature:

Personal Project Brief – IDE Master Graduation Project

TU Delft

Name student Sophie Busch

Student number

PROJECT TITLE, INTRODUCTION, PROBLEM DEFINITION and ASSIGNMENT

Complete all fields, keep information clear, specific and concise

Project title

Packaging free delivery and operations at Oslo Airport terminal

Please state the title of your graduation project (above). Keep the title compact and simple. Do not use abbreviations. The remainder of this document allows you to define and clarify your graduation project.

Introduction

Describe the context of your project here; What is the domain in which your project takes place? Who are the main stakeholders and what interests are at stake? Describe the opportunities (and limitations) in this domain to better serve the stakeholder interests. (max 250 words)

Significant volumes of waste are generated during the operation of the airport and the energy consumption and waste removal of busy airports resemble that of major cities (Sreenath et al., 2021). Avinor's role in society is to own, operate, and develop a national network of airports for the civilian sector and joint air navigation services for the civilian and military sectors in Norway (Avinor, n.d.-b). In regards to the circular economy, Avinor aims to work for optimal use of resources so that they reduce the need to take out new natural resources (Avinor, n.d.-a). The assignment is part of the EU-funded TULIPS project work package 6, dedicated to the elimination of operational consumer/passenger waste (TULIPS, 2020), and will take place at Oslo Airport with Avinor. The aim is to investigate the feasibility of both reducing packaging and finding reusable packaging alternatives for commercial operations in collaboration with commercial units and their suppliers. The main stakeholders are; Avinor, commercial units and suppliers, the TULIPS project, and indirectly the community and travelers. People who come in direct contact with the supply packaging of commercial goods during operations are the main stakeholders, these are people working at the terminal in the airport, at for instance airport operations, food, and beverage stations, cleaners, or shops. The main opportunity is limiting packaging needed in commercial operations and going towards a circular economy, for supply packaging, making supply operations more sustainable, and establishing a closed-loop system, see Figure 1.
Since the domain of packaging is very broad the topic is narrowed down to supply packaging waste in the operation and transport of commercial units inside the terminal, leaving out other supply packaging waste that has to be tackled as well. It is also unachievable to know for sure what the airport will look like in 2050, making for speculative scenarios, but the future vision in the roadmap can still be achievable. Financial limitations could also come to light, due to underlying costs. Some personal limitations are that the project only covers businesses inside the terminal and my work will mostly be done remotely, with three visits of each a week, this means a very limited time on site of the project.

→ *space available for images / figures on next page*

Avinor. (n.d.-a). CIRCULAR ECONOMY - Avinor. https://avinor.no/en/corporate/sustainability2/circular-economy/circular-economy
Avinor. (n.d.-b). Role in Society - Avinor. https://avinor.no/en/corporate/about-us/role-in-society/role-in-society
Sreenath, S., Sudhakar, K., & Yusop, A. F. (2021). Sustainability at airports: Technologies and best practices from ASEAN countries. Journal of Environmental Management, 299, 113639. https://doi.org/10.1016/j.jenvman.2021.113639
TULIPS. (2020). Projects - TULIPS. https://tulips-greenairports.eu/tulips-projects-and-demonstrations/

introduction (continued): space for images

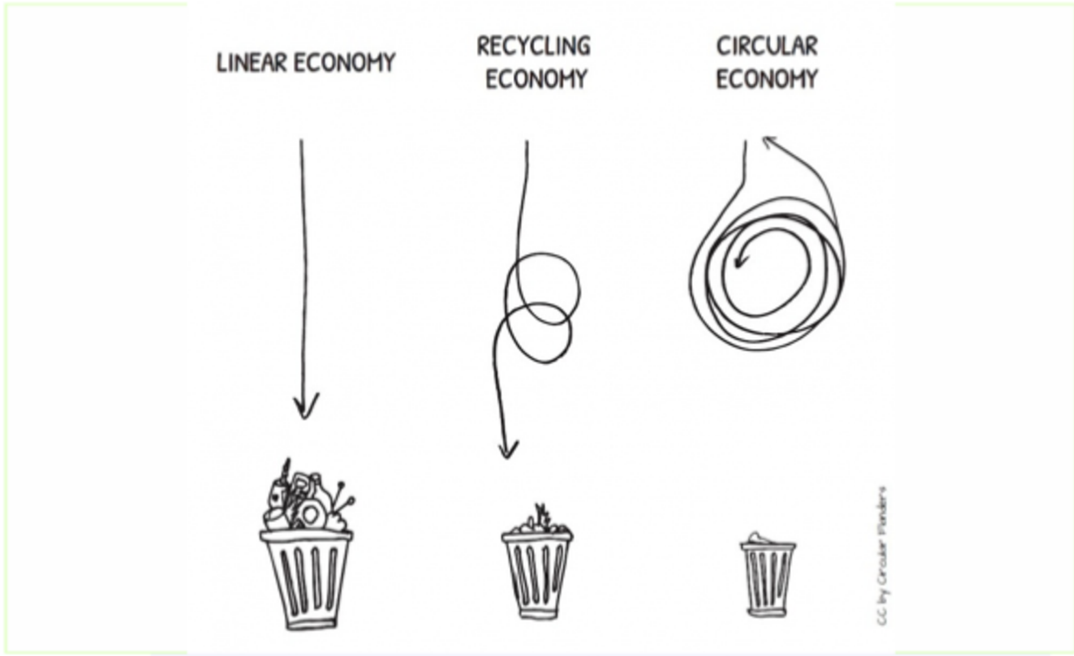


image / figure 1 Linear vs Recycling vs Circular retrieved from https://www.agion.be/circulair-bouwen

image / figure 2

Personal Project Brief – IDE Master Graduation Project

Problem Definition

What problem do you want to solve in the context described in the introduction, and within the available time frame of 100 working days? (= Master Graduation Project of 30 EC). What opportunities do you see to create added value for the described stakeholders? Substantiate your choice.
(max 200 words)

Significant volumes of waste are generated during the operation of the airport and the energy consumption and waste removal of busy airports resembles that of major cities (Sreenath et al., 2021). Airports need to find ways to eliminate their waste, especially in commercial travel and operations supply packaging. However, it is still unclear what packaging could be reduced without compromising the integrity and quality of goods and different stakeholders give different meanings to quality and integrity, sustainability, and face different challenges. Avinor aims to work for optimal use of resources so that they reduce the need to take out new natural resources (Avinor, n.d.-a) and invest in a more sustainable future. However, businesses also have other needs, for instance, to keep costs down in the supply chain or cleaning companies have specific regulations regarding packaging. This makes for different priorities, causing them to not work together at the same pace or in the same way to find a solution and making one solution not applicable to all.
For this project, the challenge is to find a way for commercial units in airports to make their packaging during supply operations more sustainable and find possible ways to work together and combine needs. An opportunity to create added value would be to enhance the supply chain efficiency with the supply packaging solution. Another interesting opportunity is the scalability of the solution. If the solution is applicable on multiple locations it would be interesting to see how this can help multiple airports.

Assignment

This is the most important part of the project brief because it will give a clear direction of what you are heading for. Formulate an assignment to yourself regarding what you expect to deliver as result at the end of your project. (1 sentence) As you graduate as an industrial design engineer, your assignment will start with a verb (Design/Investigate/Validate/Create), and you may use the green text format:

Create a roadmap to define a plan for the supply packaging of products and design and test a supply packaging concept for 2030 to go towards a more circular economy for Avinor and terminal operators at Oslo airport.

Then explain your project approach to carrying out your graduation project and what research and design methods you plan to use to generate your design solution (max 150 words)

For this project I will work in three phases;
In the first phase I will establish the problem, what is already known, and the future vision. Starting with a literature review on similar cases (airports, shopping malls, etc) to investigate how these projects are tackled in different contexts. During the first field trip, I will observe supply operations (observational study) and conduct interviews to come to a stakeholder and value map to map the problem areas and identify opportunities.
The second phase will be the concept phase, in which I will set goals and develop concepts for supply packaging operations per horizon (2030, 2040, and 2050) based on my previous research and through co-creation and evaluation with stakeholders during the second visit to Oslo. I also plan to do a first feedback session on ideas generated before the visit to get initial feedback to iterate with. I will narrow down these ideas towards the most promising and packaging-limiting solutions for the Roadmap. The last phase will be to prototype and test part of the solution for 2030 to come to a concept that is usable at Oslo airport in the short term. I have to evaluate which short-term solution has the most impact and is feasible in the short term and select one. This solution will be tested during the last visit to Oslo.
Lastly, throughout the whole process, I will document and report all my findings and research.

Project planning and key moments

*To make visible how you plan to spend your time, you must make a planning for the full project. You are advised to use a Gantt chart format to show the different phases of your project, deliverables you have in mind, meetings and in-between deadlines. Keep in mind that all activities should fit within the given run time of 100 working days. Your planning should include a **kick-off meeting**, **mid-term evaluation meeting**, **green light meeting** and **graduation ceremony**. Please indicate periods of part-time activities and/or periods of not spending time on your graduation project, if any (for instance because of holidays or parallel course activities).*

Make sure to attach the full plan to this project brief.
The four key moment dates must be filled in below

Kick off meeting	12 Feb 2024
Mid-term evaluation	9 Apr 2024
Green light meeting	14 Jun 2024
Graduation ceremony	12 Jul 2024

In exceptional cases (part of) the Graduation Project may need to be scheduled part-time. Indicate here if such applies to your project

Part of project scheduled part-time	
For how many project weeks	
Number of project days per week	

Comments:

Motivation and personal ambitions

Explain why you wish to start this project, what competencies you want to prove or develop (e.g. competencies acquired in your MSc programme, electives, extra-curricular activities or other).

Optionally, describe whether you have some personal learning ambitions which you explicitly want to address in this project, on top of the learning objectives of the Graduation Project itself. You might think of e.g. acquiring in depth knowledge on a specific subject, broadening your competencies or experimenting with a specific tool or methodology. Personal learning ambitions are limited to a maximum number of five.
(200 words max)

I came across the assignment on the graduation opportunities site of Industrial Design and read the brief about packaging-free delivery and was interested immediately, because mobility and sustainability are two of my interests, and the logistical aspect aligns well with my master's program. My interest in this subject arose after writing a paper for a TU Delft subject on the amount of waste generated in hospitals. I am now also taking electives on sustainability. This issue is also prevalent at mobility hubs such as Oslo Airport. Last autumn, I traveled for over 2 months and witnessed how much waste is produced in airports. I would love to be part of a project like this, where Oslo Airport is taking a step in the right direction, and the solution hopefully serves as inspiration for other airports in European countries.
For my learning goals, the main goal for me is in project management and the different aspects of taking on such a big project. I have worked in a bigger company before and noticed that clear and understandable communication is one of the most important aspects of working with many different stakeholders. In this area, it is also important to keep developing yourself. Furthermore, in this project, I will have to gather knowledge from different parties on waste management, sustainability, and other subjects that arise. Using experts and literature and doing research in the right direction is essential to coming up with a feasible solution. Lastly, I have to keep on reflecting on this project during the whole 100 working days constantly set up the boundaries, and look back at this brief to see how this project changes. I want to set certain moments in time in my planning to reflect and iterate since it is easy to get lost in the process.

Graduation

Sophie Busch - start 12/2/2024

Day 100
Break/free days
midterm/green light

midterm
day 40

Green Light
day 80

hand in repor Day 100 - g

TAAK	VOORTGANG
Phase 1	
Desk Research	
Re-Define scope and boundaries	
Observational study	
Interviews	
Analysis of research (mapping)	
Set Future Vision	
Concept phase	
Desk Research	
Designing roadmap and concepts	
Co creation & evaluation at Oslo	
Iterate & define	
Test & evaluate phase	
Decide on concept to test	
Testing plan	
Execute testing	
Iterate & evaluate	
Practicalities	
visit 1 to avinor	
visit 2 to avinor	
visit 3 to avinor	
Finalizations roadmap & concept	
Report Finalizations	
Presentation Prep	
Supervisory meeting	

(have to plan with other students)

(have to plan with other students)