VertiGarden

Product report

/ AALBORG UNIVERSITY
/ SPRING 2023
/ INDUSTRIAL DESIGN
/ MSC04-ID012

Eiden arredondo Harmen
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Title page

Title	VertiGarden
Theme	Waste reduction
University	Aalborg university
Study	Industrial design
Group	MSc04 / Group 12
Project start	01/02-2023
Submission	31/05-2023
Main supervisor	Mário Barros
Co-supervisor	Benney Endelt
Pages	20

Laura Moreno Huang

Eiden Arredondo Harmen

Table of content

Reducing waste

The project VertiGarden started by wanting to reduce waste that is produced in restaurants. During the project period, it was found that the best way to introduce a product to tackle this is through a vertical garden. The reason for this is the desire of the chefs to have their own place to grow some greens and the impact of locally source food.

VertiGarden is a vertical garden designed for restaurants. It consists of two units that are placed in the dining area of a restaurant and provides 6 kg of microgreens and 4 kg of leafy greens a week. This is enough for the restaurant to be self-sufficient. An app is installed on the phone and connected to the vertical garden so it can keep track of what has been planted and when.

How it works

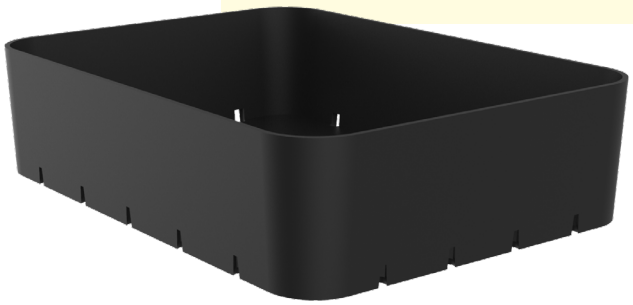
VertiGarden is an automatic vertical garden that uses a motherboard to control the timers of the lights, fans and watering system.

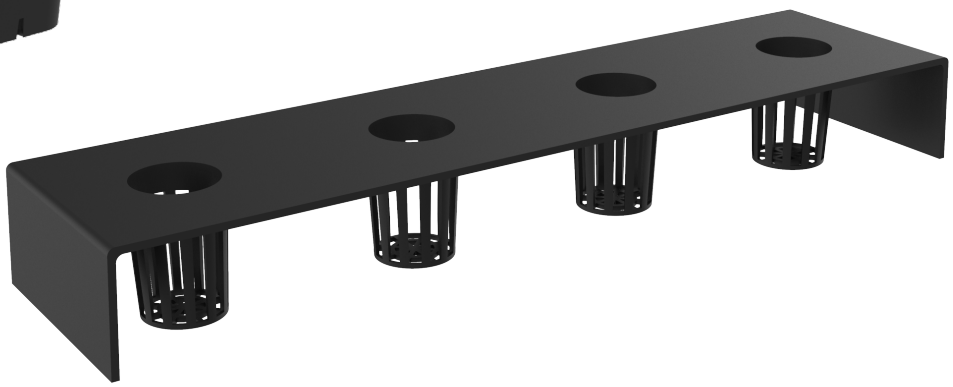
How to use VertiGarden

VertiGarden is has a few verty simple steps to set it up and running. Once the germination process has started all the user has to do is wait untill the app sends them a notification that the greens are ready to be harvested.

During the waiting process the app may send the user a notification, to fill up the tank, or to start germinating if a collection has been programed.

The leafy greens seeding and harvesting process is very similar to that of microgreens with the difference that there is no germination required.





1.

Soak the hemp mat

Make sure the mat has absorbed the water

2.

3.

Place the mat in the microgreen tray

Fill up a table spoon

4.

5.

Spread them around the matt as even as possible

With the water spray, spray the seeds

6.

7.

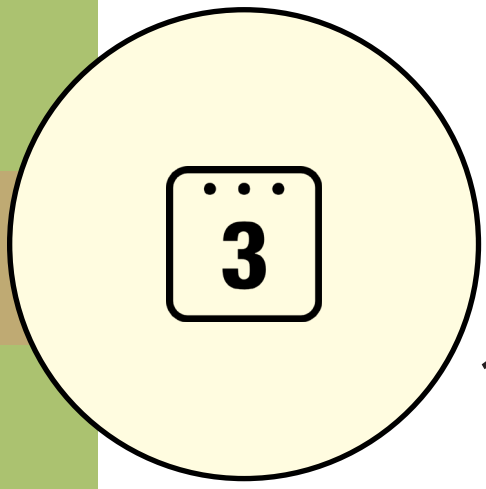
Spray the surface of the weigth

Place the weigth on top of the seeds

8.

9. Place the trays in the germination drawer

Let them stay there for 3 days



10.

11. After the 3 days open the drawer and take the weight off

Place the trays in the watering tray under the ligtht

12.

Make sure the light and all electronics are working fine.
Let them sit there for 7 days

13.

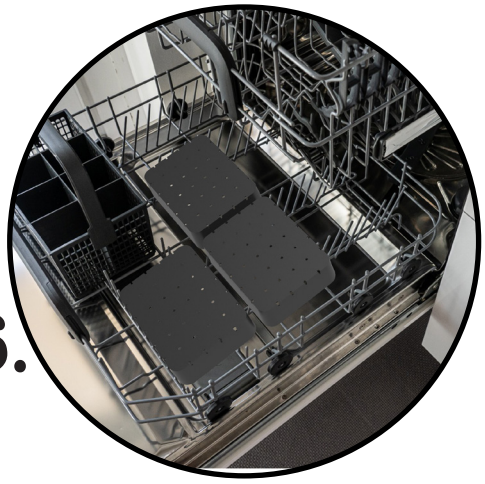
14.

When ready to eat, take a clean sharp knife and cut 1cm over the pad

15.

Ready to use in delicious dishes

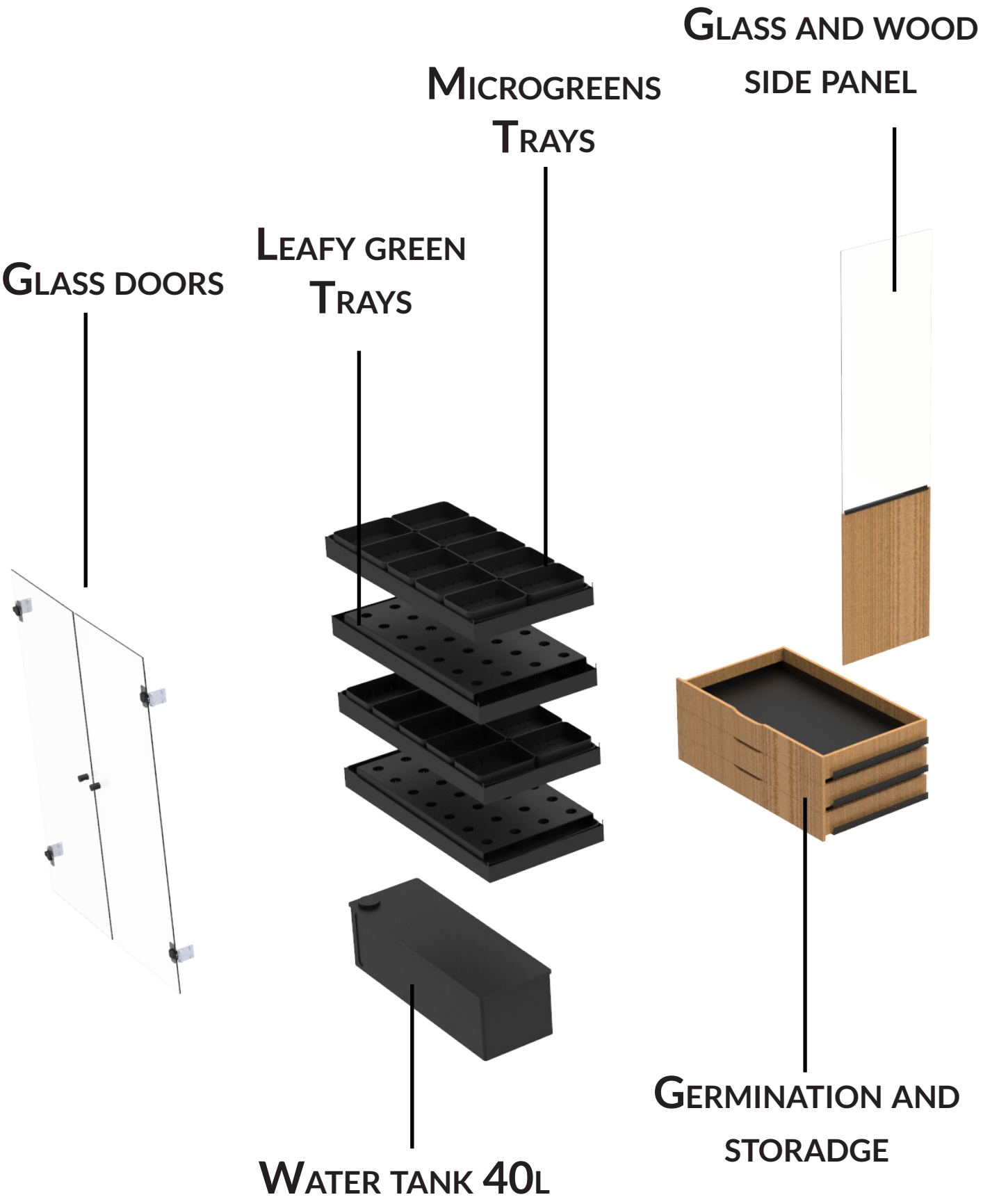
Place the trays in the dishwasher

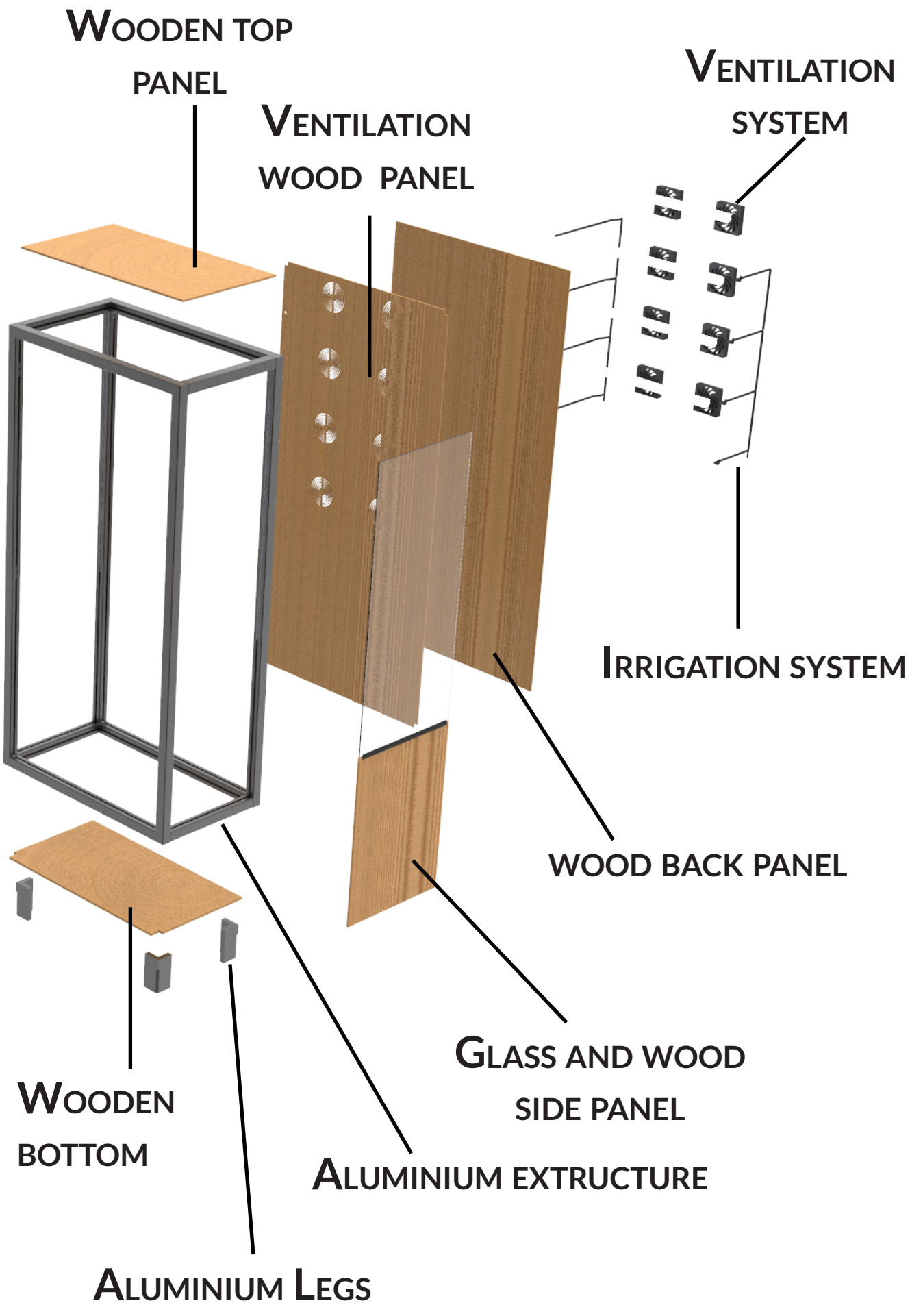


16.

Ready to start a new bach!

17.

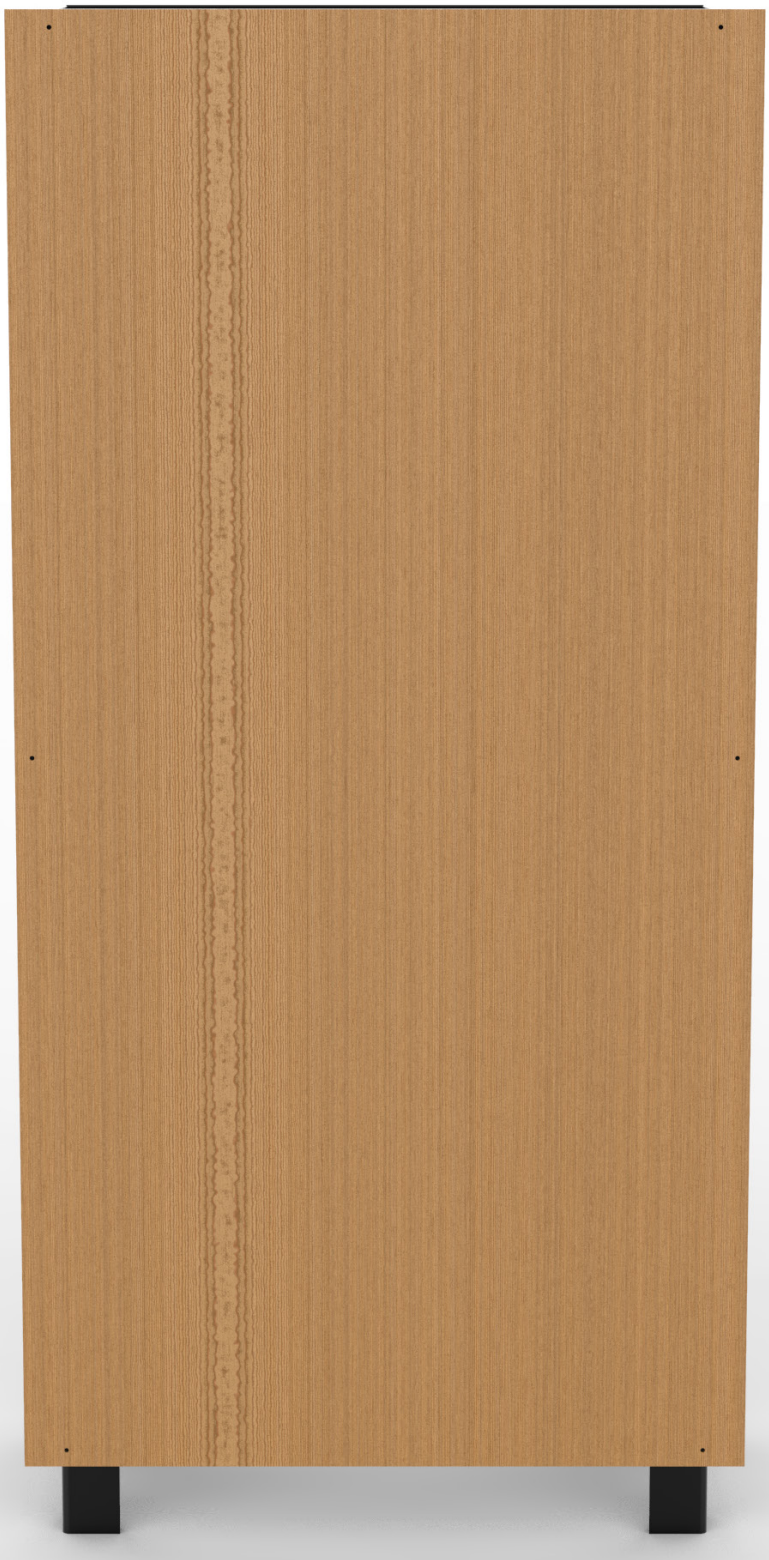

Glass and wood
side panel
Microgreens
Trays
Leafy green
Trays
Glass doors
Germination and
storadge
Water tank 40l


WOODEN TOP PANEL
VENTILATION WOOD PANEL
VENTILATION SYSTEM
IRRIGATION SYSTEM
WOOD BACK PANEL
GLASS AND WOOD SIDE PANEL
ALUMINIUM EXTRUCTURE
WOODEN BOTTOM
ALUMINIUM LEGS


UNOX
CHEFTOP
UNOX

VertiGarden costs approximately 8500 DKK to manufacture. The business plan that has been thought of is a leasing system. Two units of the VertiGarden, one for microgreens and one for leafy greens are leased out for only 2000 DKK a month. This allows the restaurant to save over 2000 DKK a month.

Total price for standard parts	2618,08
Total price for material microgreens	4788,00
Total price for material leafy greens	4717,32
Total price for moulds per part microgreens	370,71
Total price for mould per part leafy greens	366,49
Total price for operations costs microgreens	400,46
Total price for operations costs leafy greens	312,24
Total price for overhead microgreens	100,12
Total price for overhead leafy greens	78,06
Total price assembly per unit	308,07
Total price per unit big scale scenario for micogreens	**8585,44**
Total price per unit big scale scenario for leafy greens	**8400,27**



VertiGarden

Process report

/ AALBORG UNIVERSITY
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Laura Moreno Huang

PROCESS REPORT

PROJECT TITLE
VertiGarden

THEME
Waste reduction

PROJECT PERIOD
Spring Semester 2023
2nd of Febuary -31st of May

PAGES
86

MAIN SUPERVISOR
Mário Barros

SECONDARY SUPERVISOR
Benny Endelt

PROJECT TEAM
MSc04 / Group 12

Eiden Arredondo

Laura Moreno Huang

Abstract

The restaurant industry produces a lot of waste. A case study was performed in Skagen Fiskerestaurant where three main sources of waste were found by shadowing one day in the restaurant. These are food waste, packaging waste from fish, and packaging waste from vegetables.

The aim of this project is to provide restaurants with a solution to reduce this waste since in the current years, a sustainability trend has appeared. To do this, collaboration with the restaurants was obtained to find out their needs, and through continuous interviews, ideation, and prototyping, the project took shape.

During user interviews, a real restaurant need was found, which was that they want their own garden. Because of this, VertiGarden was designed. It provides restaurants the chance to have their own garden while at the same time reducing the packaging waste that is created throughout the whole vegetable supply chain.

VertiGarden is a vertical garden that is to be placed in the dining area of restaurants. It consists of two units, one for microgreens and one for leafy greens that respectively provide enough greens for the restaurant to be self-sufficient.

Reading Guide

This project is presented in seven parts. These parts all present or address different sides of the project and it's recommended to read them in the following order:

Product report
Process report
The product report showcases the final concept while the process report presents the process through which the final concept was developed.

The ilustrations shown on the side pop up when a requirerment or an insght are found.

Technical drawings

The technical drawings aid in understanding the dimensions of the product and how the different components relate to each other.

Appendix

The appendix provides additional information for the development process supplementing the process report.

***The Insights present key takeaways from the process that will aid in the development of the concept proposals.**

***The working Principles present how the Insights are being implemented in the concept proposal.**

Contents

Intoduction

In recent years, the restaurant industry in Denmark has been growing. With this increase in the number of restaurants, there has also been an issue with the increase in waste that is that it implies. This report aims to find a solution to reduce this waste and provide restaurants with a useful and meaningful product that will encourage them to change their current day-to-day. More specifically, the group has rethought completely the way that restaurants obtain their vegetable supplies and through this, offers restaurants their own vertical garden.

Data gathering and methods

Double diamond

The project was based on utilising the double diamond methodology to guide the process and development throughout the period. It is divided into four phases, the discovery phase, the definition phase, the development phase, and, finally, the delivery phase. During the first half of both diamonds, the process is diverging, and where information is gathered in the problem space and solution space without rejecting any possibilities. In the second half of these, the process is convergent where the information that was found is analysed to get a more concrete problem and solution. [Design Council (2023)]

Lean start-up

During the project period, the lean start-up method was utilised. Here, the iterative design was used to develop a minimum viable product, show it to the customers, learn from it, and produce a new and revised version. With the experimentation that is required during the lean start-up method, the group was able to progress in a faster manner to accommodate for the slow beginning of the project. [Blank. S (2013)]

Shadowing

Shadowing is a research technique where the researcher observes, without interfering, the participant throughout a specified period of time. This method was used to follow the chefs from Skagen Fiskerestaurant to obtain information and observations of their behaviour and time schedules during the working hours. [IDEO (2003)]

Interviews

Interviews are a data collection method where questions are asked to gather information. These were used throughout the project to obtain insights and working principles from different professionals like chefs, a vertical gardening hobbyist, and an industrial designer amongst others. [George, T. 2022]

Paper prototyping

This method is used to quickly draw out different concepts to evaluate them and begin the iterative design process. Different sketching rounds were made throughout the report to map out different directions for the project and obtain feedback from the user. [IDEO (2003)]

User scenarios

This method was used to illustrate a story describing the current scenario at a restaurant and how using the proposed concept would affect this. [IDEO (2003)]

Try-it-yourself

This method was used together with the quick and dirty prototyping to try out different interactions that the user would have with the product. With this, it was possible to obtain key insights on some interaction points. [IDEO (2003)]

Quick and dirty prototyping

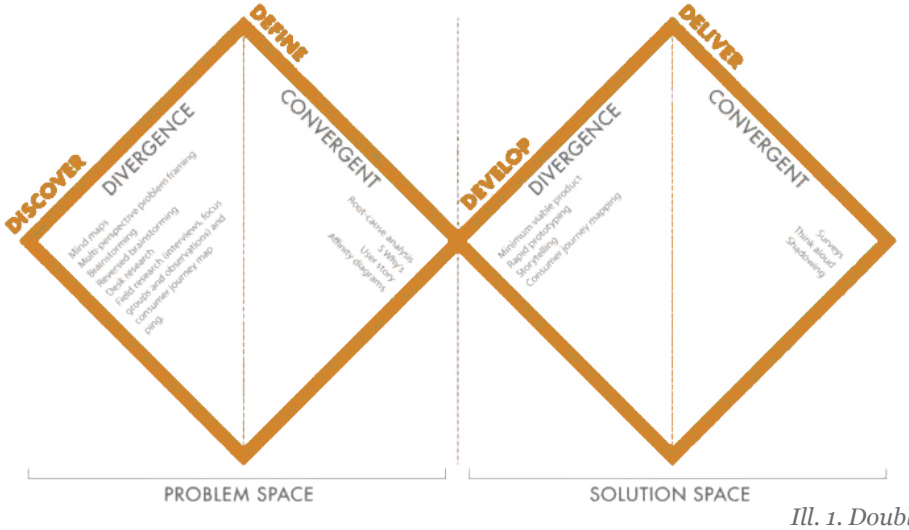
This method is used to quickly build key interaction parameters that together with the try-it-yourself method allowed the team to take some decisions for the concept. [IDEO (2003)]

Experience prototyping

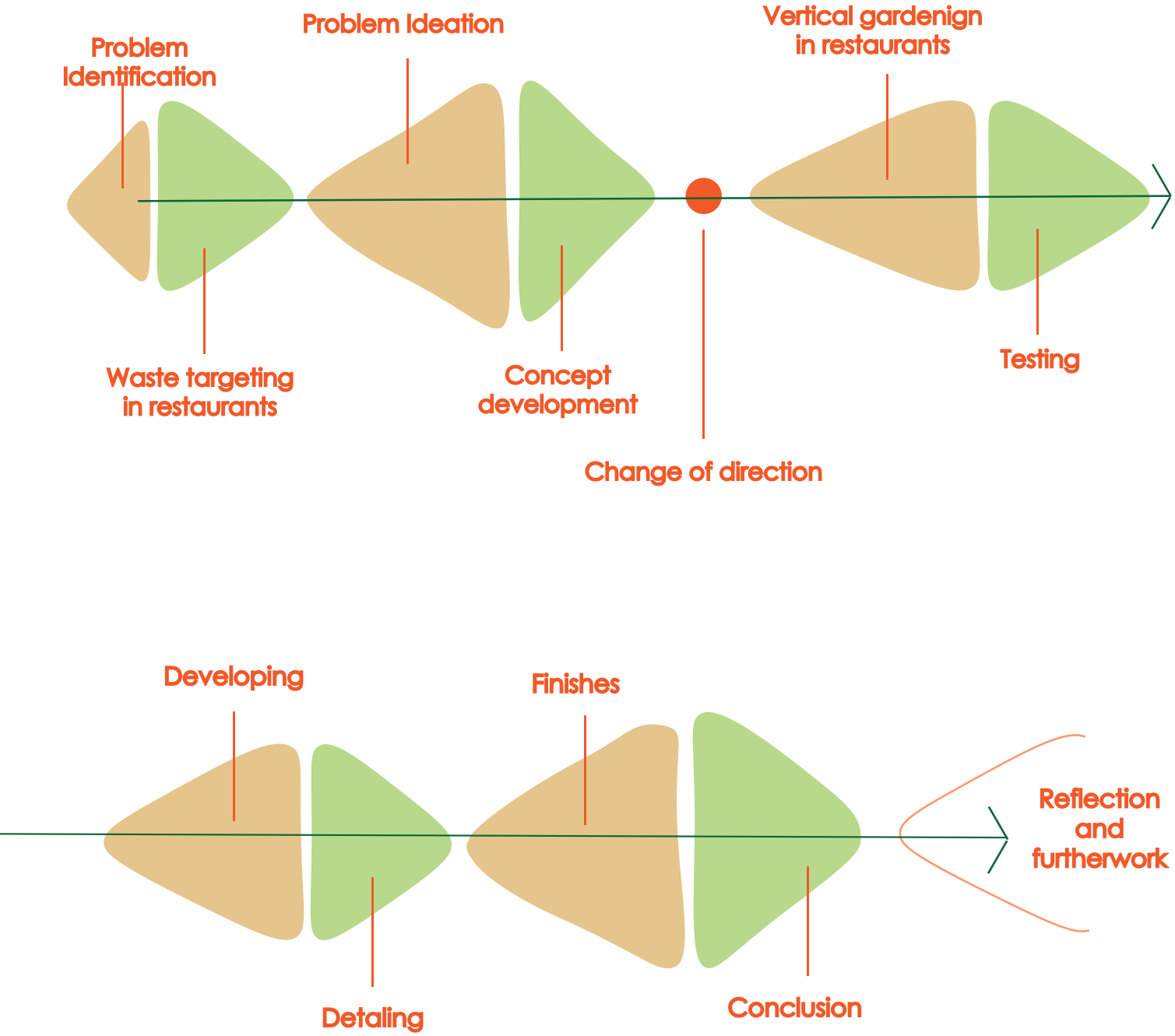
This method was used to build a prototype that was handed out to Nordur in order to obtain information and observe the usability of the product. It served to obtain important insights that later on affected the design of the product. [IDEO (2003)]

Desktop research

Desktop research is a method based on reviewing existing data and previous research on the topic that is to be studied. This method was used throughout the report to obtain a wide range of information that is publicly available and could aid the concept development. [Goundar, S. (2012)]



Ill. 1. Double diamond method (1)



Ill. 2. Process timeline

1

DISCOVER

In this chapter, the problems and challenges of this project are explored. Different methods are utilised to collect information regarding the project. All the data is collected and documented without disregarding any information. [Brown, V. (2023)]

During the discovery phase, the team gathered information and insights from various sources, including initial brainstorming sessions, interviews with potential users, experts in the relevant field, and visits to possible users. Through this process, the team identified a problem in the supply chain regarding waste in the delivery of greens for restaurants. Based on these findings, it was determined that an industrial design product could potentially solve this challenge.

Problem introduction

In this section, desktop research is done to explore how much waste is generated in the restaurant industry in Denmark. From different experiences, an assumption is made that there are two types of waste, food waste and packaging waste.

The restaurant industry has been experiencing significant growth, with projections indicating continued expansion in the years ahead. According to IBISWorld, there are currently 10,667 restaurants in Denmark as of 2023, which represents a 3.5% increase from the previous year [IBISWorld (2023)]. However, this growth is expected to result in a corresponding increase in waste generated by the industry [Miljø- og Fødevareministeriet (2019)].

In 2018, the Danish food ministry conducted a study that revealed that approximately 71,000 tons of food waste are generated annually by the restaurant industry. Of this amount, around 42,000 tons consist of food that could have been consumed, while the remaining waste includes items such as banana and carrot peels [Miljøministeriet (2021)].

Furthermore, a 2019 report by the same ministry found that the restaurant and hotel industry produces 1,300 tons of plastic waste each year. Shockingly, only 10% of this waste is recycled. It is important to note that this figure does not include plastic packaging that is given to customers, as is common in fast food establishments [Miljø og Fødevareministeriet (2019)]. The desktop research presented is only on plastic waste because it has not been possible to find numbers for cardboard packaging waste.

The impact of this waste on the environment is significant, as it contributes to the global issue of climate change and environmental pollution. Food waste produces methane gas when it decomposes in landfills, which is a potent greenhouse gas that contributes to climate change [Buzby, J. (2022)]. Additionally, plastic waste takes hundreds of years to decompose and can harm wildlife and ecosystems, leading to negative impacts on the planet's biodiversity *[Pinto Da Costa, J. and Rocha-Santos, T. and Duarte, A. (2020)] [Fava, M. (2022)].* This paragraph is more for a global perspective. In Denmark, the waste is burnt to create enegry.

Ill.6 SDGS 11.12.13

Ill. 3 Restaurant cardboard container

Ill. 4 Plastic waste

Ill. 5 Restaurant food waste

Problem Understanding

In the problem introduction page, data is gathered that shows why tackling waste from the restaurant is important. With the increasing number in restaurants, the waste is also expected to increase. There are aleady 71000 tons of food waste and 1300 tons of plastic waste out of which only 10% is recycled. The aim with this report, as mentioned, is to provide restaurants with a solution to reduce this waste.

Interviews about waste

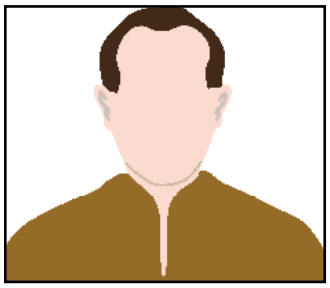
To understand how waste is handled in restaurants nowadays, two interviews are made with two chefs from different restaurants. The aim of these is to find out, among other things, what type of waste there is, how much, how they handle it, and if they are doing anything to reduce these amounts.

EST. 1970
SKAGEN
·FISKERESTAURANT·

Ill. 7. Skagen logo

Skagen Fiskerestaurant

From the interview and observations with the chef in Skagen Fiskerestaurant, it is possible to gather that chefs, in this restaurant, sort waste according to three categories, these are:



Chef
-In charge of the kitchen
-Ordering food
-Cooking
-Weekly / Monthly menu
-Inventory

-Residual waste
In the restaurant, they do not have compost bins for food waste so it all goes into a residual waste bin. Here, contaminated soft and hard plastic packaging can be found together with contaminated cardboard packaging. By contaminated it is meant that they have food residue.

-Hard plastic waste
Most of the hard plastic packaging they receive are big boxes for microgreens or vegetables. Because of this they do not usually have residual waste in them and can easily be put apart to be recycled.

-Cardboard waste
In this category, big cardboard boxes can be found. These cardboard boxes are normally used to keep a few smaller items together and can therefore also be easily recycle.

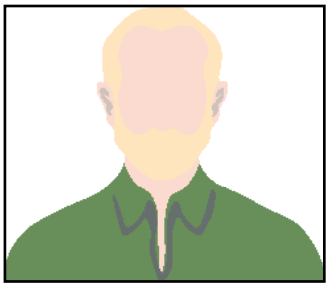
In this restaurant, no initiatives are taken to reduce waste because of the added costs that it would suppose for the restaurant. This is because their supplier charges them if they want to use reusable plastic boxes. A number for how many kilos of waste there was at the time in this restaurant, could not be obtained during the interview. The chef however, gave the group permission to shadow them for a day to observe and gather data as to where the waste comes from.

Reusable packaging cases are not been used as they required extra space and a deposit from the restaurant to ensure they are not damaged.

The chefs would have to spend time rinsing out the packaging before recycling. A more convenient solution is used which is just to place it in the residual bin.

AKTUEL (smørerbrød)

Ill. 8 Aktuel logo



Head chef
-In charge of the kichen
-Ordering food
-Cooking
-Weekly / Monthly menu
-Inventory

Having interviewed the chef in Aktuel, it is possible to gather that the chef here is already taking some initiatives to reduce waste, more specifically, food waste. Some of these initiatives are:

-Ordering locally
The chef orders food locally so that they can order food on a daily basis and in smaller quantities.

-Using peels and other parts of the food to make broths and soups
The chef uses peels and other parts of the food that would not go into the plates that they serve in order to prepare some broth. This allows them to use the food to its maximum extent.

-Feeding livestock with the leftover food
Food that is leftover from the customers or that is not used for preparing the broths is collected and handed to local farmers so that they can feed their livestock.

Conclusion

In neither restaurant, initiatives are taken to reduce packaging waste. This packging is only sorted when convenient enough as the chefs do not want to spend time rinsing it out. From here on, it will be assumed that this is a general theme for most restaurants, even though no evidence of this has been found.

That said, there are some restaurants that take the initiative in reducing food waste. This is done in various ways as was explained by the chef from Aktuel.

Both chefs acknowledge that there is a lot of packaging waste that they would like to reduce. Further knowledge is needed as to where this packaging waste comes from, to do this, it is necessary to know the full supply chain of the products.

The concept proposed should become a part of their day to day and not an inconvenience for them as otherwise it will get neglected

FURTHER WORK:

So far, the information gathered is within the restaurant. Further research is needed to figure out if there is any other sources of waste produced along the supply chain, before the products arrive to the restaurant.

Requirements for waste processing in restaurants

Desktop research is made to find out what the current regulations and requirements are in restaurants for waste management. The requirements for waste processing in restaurants vary depending on the municipality and specific regulations in place. However, there are common requirerments for waste processing in restaurants: (Vesthimmerlands, 2008)

1. Waste segregation: Restaurants should have a system in place to segregate different types of waste, such as food waste, recyclables (plastic, glass, paper), and non-recyclable waste. This requires to have separate bins for each waste type.

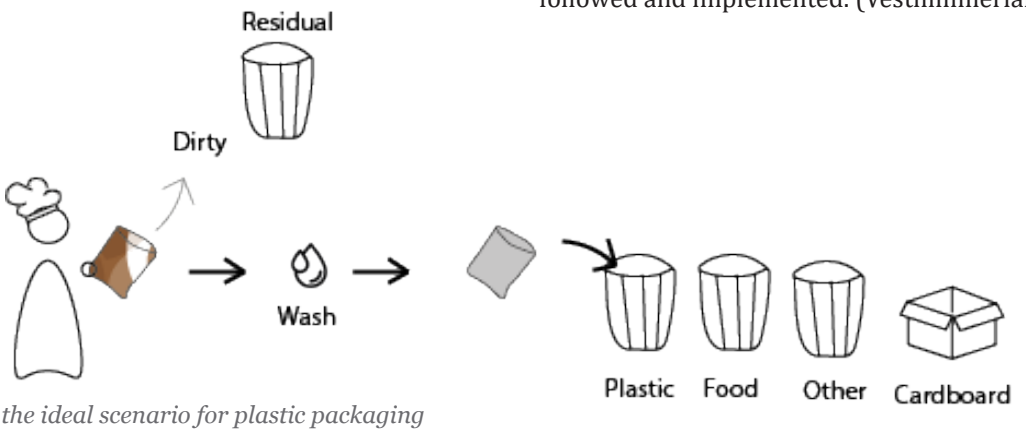
2. Recycling: Restaurants should ensure proper recycling practices for materials like paper, cardboard, plastic, glass, and metal. Each category has its own regulations. For example, plastic packaging contaminated with food waste should be previously rinsed.

3. Grease trap maintenance: Restaurants that generate a significant amount of grease and fats must have grease traps installed and regularly maintained to prevent blockages in the sewer system.

4. Hazardous waste handling: Restaurants should handle hazardous waste, such as cleaning chemicals, in accordance with local regulations. This may involve proper storage, labeling, and disposal through licensed hazardous waste management services.

5. Waste disposal contracts: Restaurants may need to have contracts with licensed waste management companies for the regular collection and disposal of different types of waste.

It is important for restaurant owners and managers to familiarize themselves with local regulations and work with waste management professionals to ensure that they are followed and implemented. (Vesthimmerlands, 2008)



Ill.9. Example of the ideal scenario for plastic packaging

Summary of the information gathered so far

So far, it has been found that restaurants recycle and sort waste when it is convenient. This means that if the packaging needs rinsing it simply goes into the residual waste. To aim of the project is to reduce waste and simply recycling it is not considered to be sufficient. A more concrete and defined scope is needed so that the group can find a direction to start the concept development since, up until now, the project is not defined enough.

Repeated insight, when sorting waste in the recyling bins, the waste should not be contaminated.

Having many different containers for recycling requires a certain amount of space to accomodate for them all.

Shadowing

To get a better understanding of where all the different waste comes from in restaurants, a case study is performed on a restaurant in Aalborg called Skagen Fiskerestaurant. Here the shadowing method is used to follow the chefs around and observe where the different waste is generated. During this process, instead of allowing the chefs to throw out the waste, it is collected and sorted into different piles. With this done, their weight is measured and noted. Visit Appendix 01 for more detailed information.

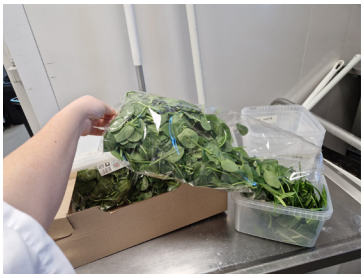
Ill.10. AB catering delivery

Ill.11. Skagens kitchen

The day starts by talking and interviewing the chefs. AB Catering is supposed to deliver the supplies before 10 am but did not arrive until 12 pm. At this point, the service had alreayd started. This delay caused a chain delay on the chefs since they had to prepare the lunch service before it started. The day usually starts by the chefs unpacking and organising the supplies received from AB Catering. These supplies are in some cases, packed into condi boxes (plastic reusable boxes that they store in the fridge). The chefs find this process quite annoying. In addition, all the packaging needs to be thrown out.

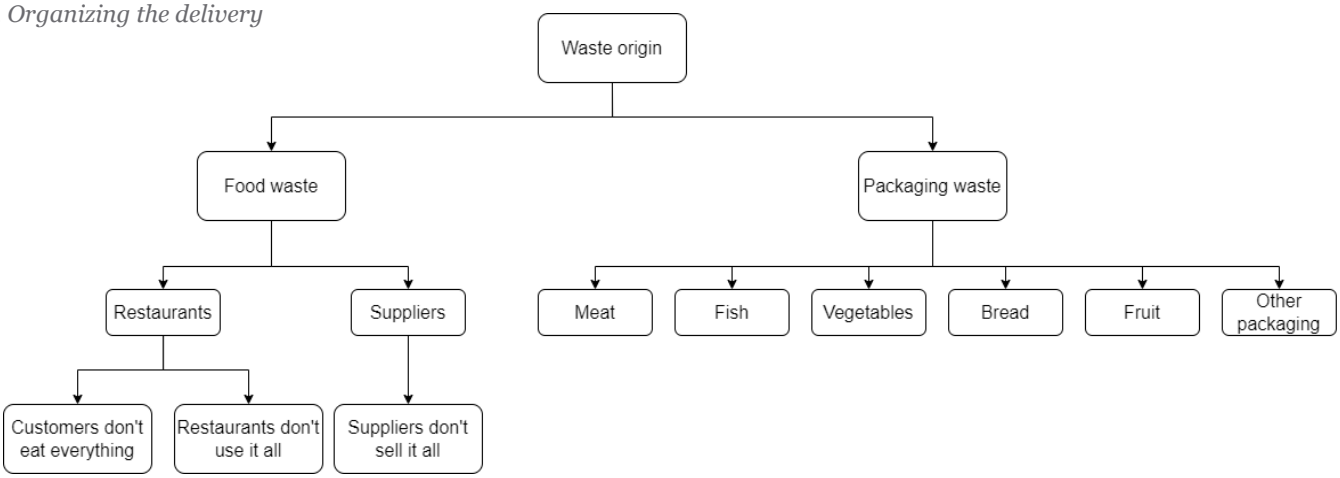
The group did not interfere with the chefs routine so that the real scenario could be observed.

However, after the chefs throw out the waste, the group then collects and sorts it so it can be weighed in the different categories.



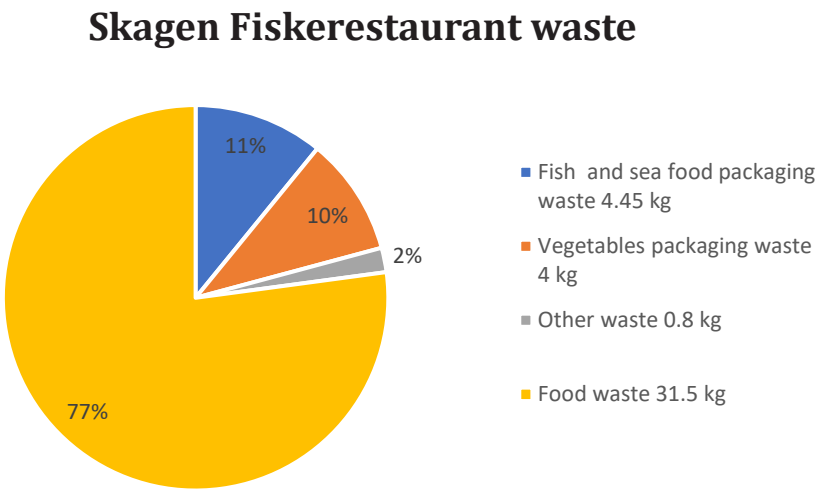
Ill.12. Organizing the delivery

The diagram below shows a visual representation of the origin of the waste. This diagram is based on observations in the restaurant and talks with the chefs.



Ill.13. Diagram to understand beter the origin of the restaurants waste

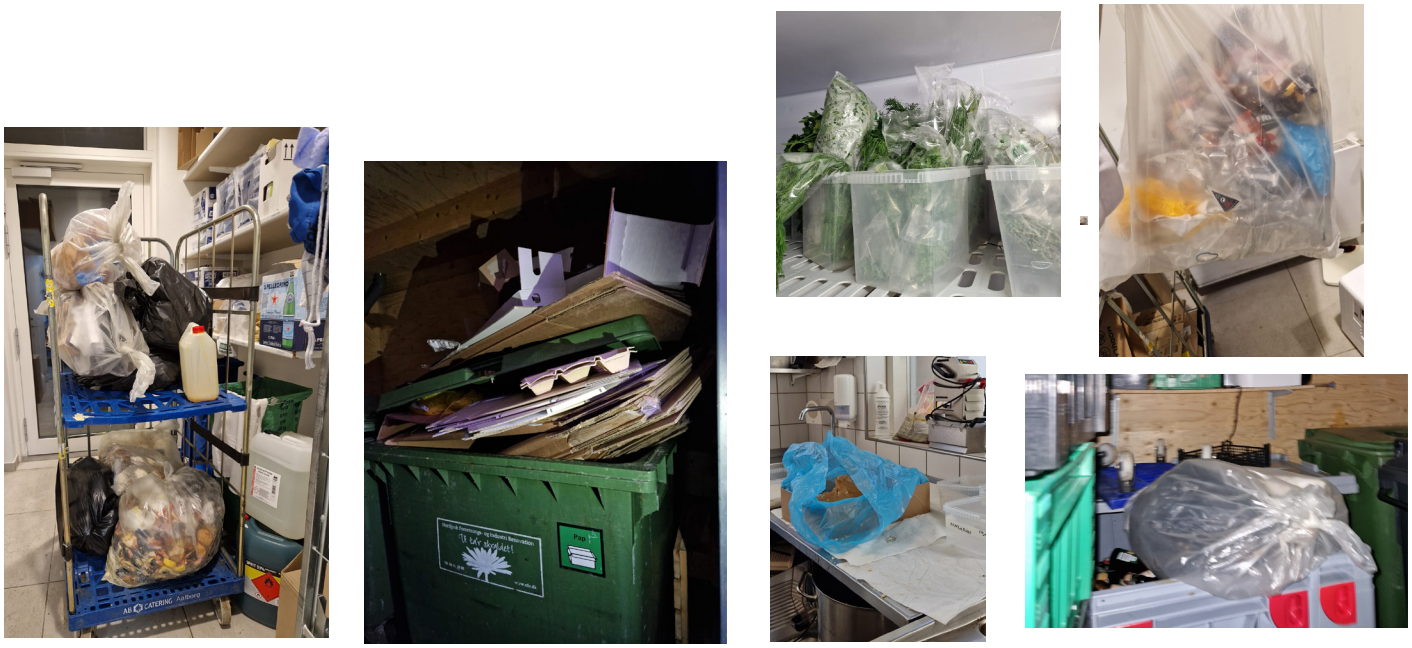
The chefs cannot rely on the supplies to be delivered on time
The supplies are taken out of the original packaging and placed in new boxes so that they can be placed in the fridge
Chefs do not sort unless it is convenient. This is done with for example big cardboard boxes and big plastic containers.



Ill.14. Pie chart showing the percentage of waste from each category that was found during the shadowing

The pie chart above shows the percentage of waste that there is from each sector. Food waste is by far one of the biggest problems that is to be tackled by restaurants. Apart from this one, fish packaging waste and vegetable packaging waste are the next two biggest contributors of waste.

The collection of images below shows all the different waste that was observed and cllected during one day of shadowing in Skagen Fiskerestaurant



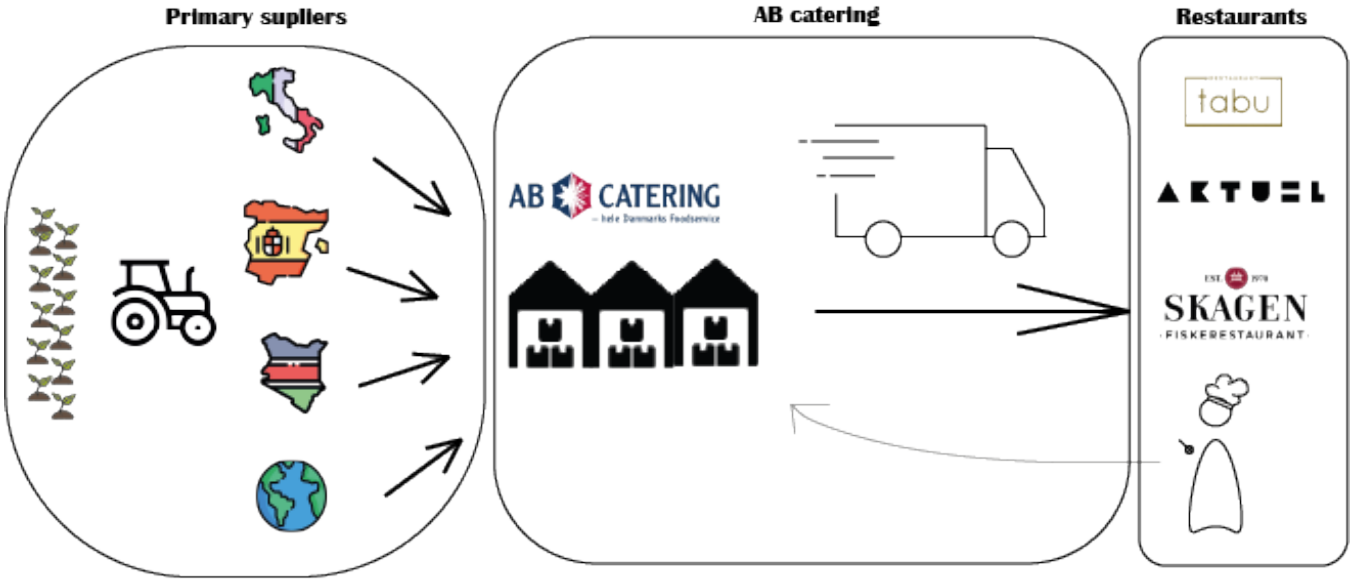
Ill.15. Trash from Skagensfiske restaurant

FURTHER WORK

Some further understanding is needed as to why there are these amounts of waste in the restaurant and if it is possible to design a product to reduce some of this waste. The following chapters will aim to investigate the full supply chain and where it is possible to find a solution to cut down on packaging waste.

Full supply chain

As, metioned previously, it is necessary to find out how the whole supply chain works to figure out if there are any other sources of waste other than at the restaurant. During the shadowing, Kim Kristensen´s contact is obtained. He is the boss of the driving department for AB Catering, the supply company that Skagen Fiskerestaurant uses, and is interviewed to obtain information as to how AB Catering´s supply chain works. The Illustration below shows how AB Catering collects food supplies from other countries and when an order is placed, they deliver it to the restaurants. AB Catering supplies Skagen Fiskerestaurant with everything except alcoholic drinks and most of the fish.



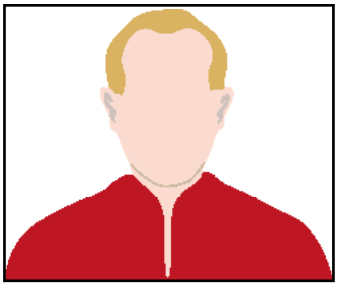
Ill.16. Current supply chain

AB CATERING – hele Danmarks Foodservice

Ill. 17. AB logo

AB catering

AB Catering collects food from other suppliers around Europe and distributes them to restaurants in Denmark. To find possible sources of packaging waste and to understand how AB catering works, a structured interview was organised with Kim Kristensen, the boss of the driving department. The interview can be found in Appendix 02. The main insights can be seen below:



Kim Kristensen
Boss of driving department

Most of the supplies they receive are from southern Europe

The supplies they recieve are in big cardboard boxes wrapped in plastic film. The film is then recycled and the boxes are sometimes used to deliver goods

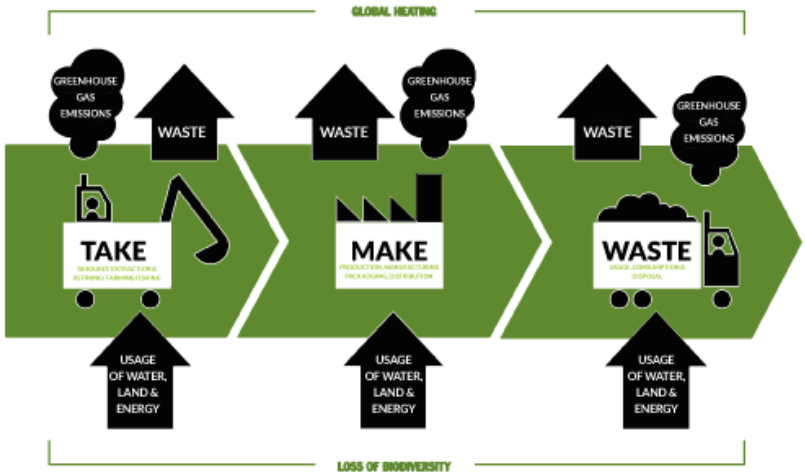
Reusable packaging is only used when asked for by restaurants. It implies they have to pay a deposit so the boxes are not damaged

REFLECTION AND FURTHER WORK

This activity gives way to visualising where the different waste is generated. An observation made is that the food has to travel long distances and, in some isntances, stored in a warehouse for up to two days. This means that sometimes, the food is not fresh when arriving to the restaurant. Additionaly, the transport involves CO_2e emissions and these are to be calculated in a later stage.

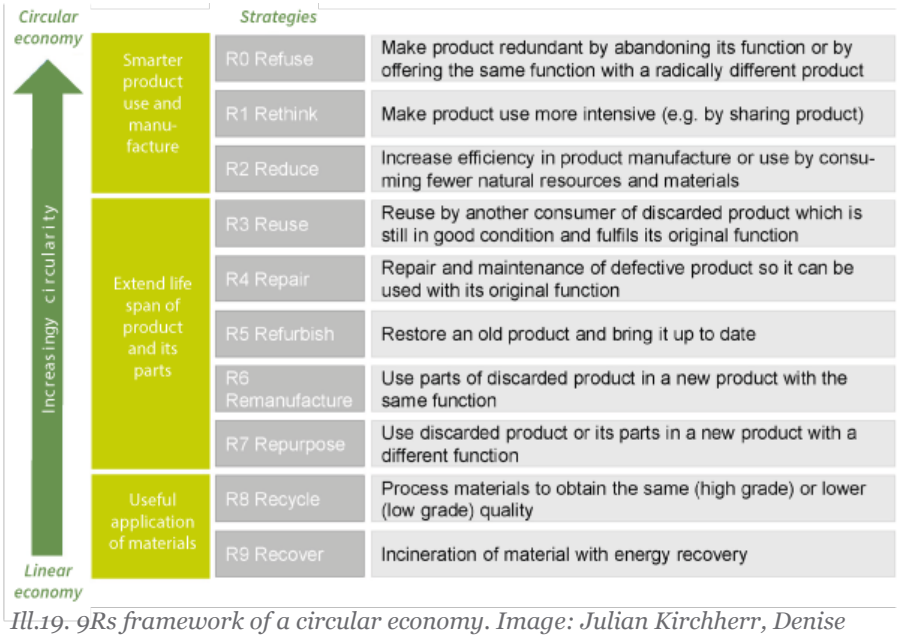
Circular economy

So far, different sources for waste have been found. Most of the waste is generated in the restaurants but during the supply chain some waste can also be found. The most common solution used is to recycle, when possible, the waste. This however, does not reduce waste as such but recirculates it back into the system to be used again. To find out if there could be a potentially better solution, desktop research is done to figure out how and if the circular economy can be implemented into the restaurant packaging scenery to avoid the current linear process. This linear process is known as the take, make, waste model. and can be seen below. [*Wautelet, Thibaut. (2018)]*



Ill.18. Waste model, Wautelet, Thibaut. (2018)

The circular economy aims to recirculate the waste back into the economy instead of simply throwing it out and extracting new resources [UNCTAD (2023)]. In the article "The circular economy: how it can lead us on a path to real change", the 9Rs framework is presented. This framework includes and orders strategic actions, from less circular to more circular, that should be introduced to address, among other issues inside global warming, waste reduction. [*Wautelet, Thibaut. (2018)*]



Ill.19. 9Rs framework of a circular economy. Image: Julian Kirchherr, Denise Reike and Marko Hekkert

Nowadays the most common solution to target waste in people's day-to-day lives is recycling. Om the table on the left, it can be seen that recycling is low on the 9r framework. The reason for this is most likely that the material still has to go through some production phases compared to some of the other presented strategies. Additionally, recycling requires additional steps as mentioned before, and therefore most of the restaurants don't bother to do it. This desktop research is used during the development phase as a tool to find solutions using the different strategies that are presented in the 9R framework. This means that when sketching, the concepts will utilise different startergies from the 9R framework.

The 9R framework provides valuable insight in regards to the possibilities to target waste reduction. The most commonly used stratergy, recycling, is second the last on the framework. This is therefore deemed necessary by the group to introduce a soution that proves to be more impactful which means utilising a stratergy higher up the ladder.

2

DEFINE 1.0

In this chapter, the information gathered previously is analysed. In contrast, to the discover phase, in the define phase, the idea is to filter the data gathered so that the project can start taking shape before entering the development phase [Brown, V. (2023)].

Compare and find direction

During the discovery phase, it was found that in restaurants there are three main sources of waste. Tackling all of them in the project timeframe is unrealistic and therefore a narrowing down of the scope is made. This is done through an analysis of the different factors and possibilities on each categories based on Appendix 03 (where research has been made on existing solutions and the current state of waste in restaurants) and Appendix 04 (for the CO2e emission calculations). The idea is to figure out in which direction, an industrial design solution can be found. The three possible directions are food waste, fish packaging waste, and vegetable packaging waste

Food waste

Represents the 77% of the waste gathered in the case study. Finding a solution for this direction would mean that, in comparison to the other two directions, a bigger impact could be made. Currently this is a big problem that attracts the attention of many. Because of this, there are already existing solutions in place like for example to good to go or stop mad spild and services for food ordering that estimate how much a person should order to avoid waste.

Ill.20. Campain logo stop food waste

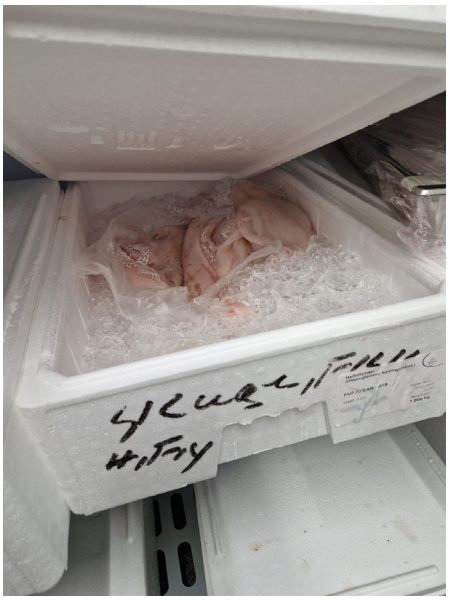
Ill.21. Logo too good to go

Ill.22. Too good to go service

Fish packaging waste

Represents 11% of the waste found during the case study. This number is assumed to be higher than it would be in other restaurants since it is a fish restaurant. Most of the waste here originates from the flamingo boxes used to transport the fish. In some cases, the fish is wrapped in two different packages. It is believed that at the time of writing this report, the flamingo boxes are collected by a specialised waste disposal company that just burn them.

Ill.23. Fish box in the restaurant



Ill.24. Sea food box in the restaurant 1

Ill.25. Sea food box in the restaurant

Vegetable packaging waste

Represents 10% of the waste found during the shadowing. The vegetables are wrapped in two or three different packages to protect them and keep them fresh during the long transport periods. In this case, the vegetables mainly arrive from souther Europe.

Ill.26. Herbs and microgreens in the restaurants fridge

Conclusion

It is possible to see that even though food waste is the greatest source of waste, it is also the direction where there are a lot of solutions available for restaurants and some are already in use here in Aalborg. Because of this, the group decided that this direction would not be the focus of the project.

To decrease the scope of the project and focus on only one type of waste, the group defines further the meaning of "reducing waste". The group defines reducing waste as reducing the amount of CO2e that is produced along the life cycle of the packaging. Appendix 04 is used to calculate the CO2e emissions from the packaging and the transport. The CO2e emissions found for the fish packaging are of 11.68 kg whereas the emissions for the vegetable packaging and transport are 20.85 kg. It is possible to see that even though there is more fish and seafood packaging waste, the CO2e emissions they cause are not as high as the emissions for vegetable packaging waste. It is believed that the reason for this is that the vegetables arrives from various different countries (mainly in southern Europe) in contrast to the fish and seafood that arrives mainly from Norway. The emissions from transportation being the biggest contributing factor. Because of this, it is decided to focus on vegetable packaging waste. More potential is seen in reducing waste on a long supply chain in comparison to a smaller supply chain that the fish packaging goes through.

Reduce emissions from the supply chain for vegetables. The current supply chain emits 5.32 kg of CO2e from packaging waste daily in restaurants, and 15.53 kg of CO2e from transport weekly.

#	Insigth	Source	Working principle
1	Reusable packaging cases are not been used as they required extra space and a deposit from the restaurant to ensure they are not damaged.	Interviews with cheffs	
2	The chefs would have to spend time rinsing out the packaging before recycling. A more convenient solution is used which is just, to place it in the residual bin.	Interviews with cheffs	Conviniency
3	Sorting waste in the recyling bins, the waste should not be contaminated.	Waste procesing	
4	Having many different containers for recycling requires a certain amount of space to accomodate for them all.	Waste procesing	Compact
5	The chefs can not rely on the supplies to be delivered on time	Shadowing	Reliable
6	Supply dont are swicht to Condi boxes	Shadowing	
7	Chefs do not sort unless it is convenient.	Shadowing	Low time consuming
8	Most of the supplies they receive are from southern Europe	Interviews	
9	Reusable packaging is only used when asked for by restaurants. It implies they have to pay a deposit so the boxes are not damaged	Interviews	Posibility for leasing system
10	Use 9R frame work as a tool		Utilize high steps of 9R frame work

Design brief

The initial aim of the project was to reduce waste that is produced in restaurants. It has been found that restaurants do want to reduce waste and in some cases, they have already taken action. However, it has been observed, that if packaging has to be rinsed before recycling, the chefs would rather throw it in the residual waste bins. The reason for this is that it is inconvenient for the chefs.

After analysing the information found during the discovery phase, the scope of the project now focuses on reducing waste related the the supply chain and manufacturing of the packaging for vegetables.

Vision

The vision for the project is to completely eliminate waste from the packaging for vegetables.

Mission

Utilise the 9R framework to introduce, with greater impact, the circular economy into the restaurants.

Market

At this point in the project, the aim is to target all types of restaurants. However, the group is aware that different kinds of restaurants have different kinds of needs and therefore still has to be explored further

Requirerments

Well-defined demands:

- None have been found

Ill-defined demands:

- The concept should emit less than 5.32 kg of CO2e daily and less than 15.53 kf of CO2e weekly. How much less is yet to be defined.
- The concept proposed should become a part of their day to day and not an inconvenience.

3

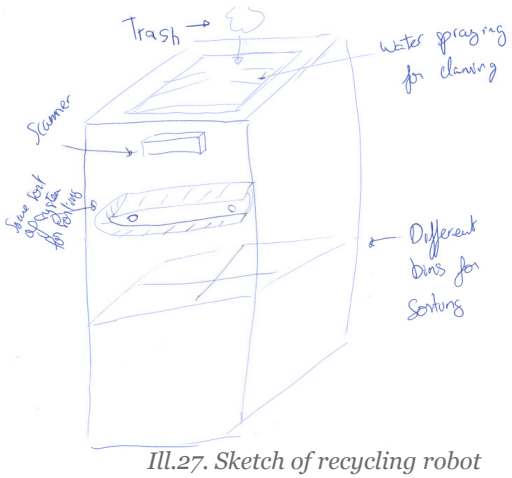
DEVELOP 1.0

In this chapter, the solution space of the project starts to be explored. The lean start-up method is utilised aiming to design a minimum viable product, learning from it, and iterating on it. [Blank. S (2013)]

As mentioned during the circular economy section, the 9Rs are to be used as a tool for the development process. This means that for each stratergy in the framework, a sketching round takes place to explore all possible options. The sketches are then evaluated by the group and presented to two chefs to get their feedback.

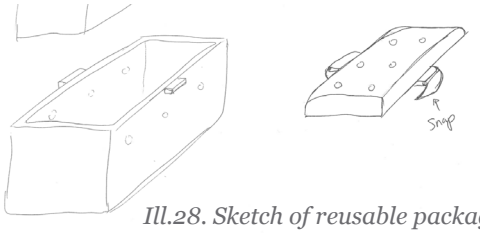
Recycle

During the sketching round for recycling, only one concept is drawn. This round is the least appealing to the group and also to the project since it is so low in the 9R framework. The idea of this concept is that it can automatically detect what type of waste is being thrown out, clean it if necessary, and finally sort it into the right pile. This makes it more convenient for the chefs since they do not need to think about sorting or rinsing.



Ill.27. Sketch of recycling robot

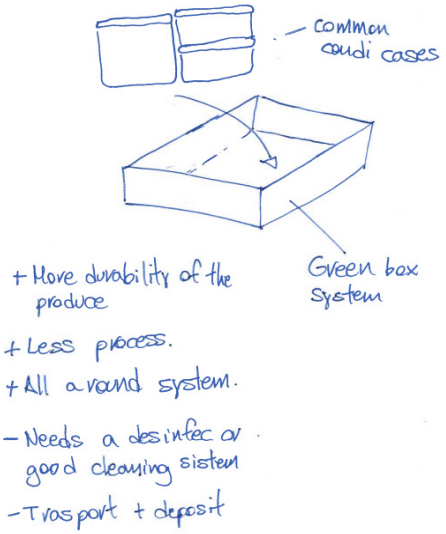
Reduce / Re-use



Ill.28. Sketch of reusable packaging 1

The idea in this sketching round is to create a system and partnership with local vegetable suppliers. To do this, a reusable packaging is designed.

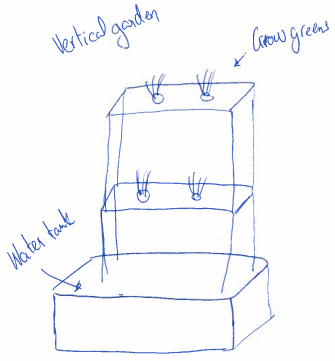
Restaurants have some aluminium boxes that are used to store vegetables that the prepare during the morning before the service. The idea would be to replace them with the reusable packaging designed.



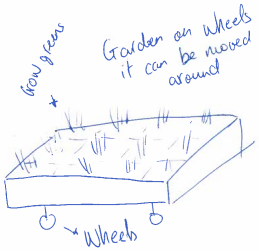
Ill.29. Sketch of reusable packaging 2

Refuse / Rethink

During this sketching round, solutions are found to completely eliminate the use of packaging. Like in the previous round, the products are locally sourced. In this case, they are grown directly in the restaurant. The solutions proposed allows restaurants to have their own vertical garden.



Ill.30. Sketch of vertical garden



Ill.31. Sketch of garden for restaurants

Main takeaways

With the sketching round done, feedback sessions are organised with two chefs. The aim with these feedback sessions is to gather insights into the wants and needs for the chefs in restaurants.

Recycle

- They were not very fond of the idea
- It takes up a lot of space that they currently do not have in kitchens
- Does not really solve the issue of reducing waste

Reduce / Re-use

- The implementation of a reusable product does not only affect the restaurant but also the supply chain.
- To completely remove the waste this needs to be implemented from the very beginning of the supply chain.
- Buying locally is not always a possibility for all the products they need. Amongst other things, because of the weather.

Refuse / Rethink

- The chefs really like the idea of having their own vertical garden. Some have already looked into it but see various challenges. Space, time and knowledge.
- If they can not be self-suficient, they do not believe it would be an option.
- Like the idea of having a farm-to-table.
- Worried about the price.
- Worried about the placement of the product.

With the feedback from the chefs, and reflecting upon making a machine to facilitate recycling, the recycling direction is removed. The main reason for this is that it does not really fix the problem at hand which is reducing waste, but it simply makes the current waste method a bit more circular.

The reduce/reuse direction implies making a service with reusable packaging for restaurants to partner up with local farmers. While this is a real possibility, it does not offer the same opportunities for restaurants in comparison to having their own gardens. Having their own garden (refuse/ rethink) would allow them to not rely on any external partners and be able to grow all year round (if it is indoor gardening). This option also aligns with the wishes from the restaurants. In addition, it is the most interesting for the group and, at the same time, the most innovative, and for those reasons is the direction chosen to be explored further.

The restaurants real wish is to have their own garden

The lack of space, time and knowledge requires some further investigation to come up with a concept

FURTHER WORK

At this point, the group realised that the actual want and need of the restaurant had actually shifted, reducing waste had become a secondary need compared to having a garden that they could use.

4

DISCOVER 2.0

In this chapter, a second round of discovery is done. The reason for this is that now, a clearer problem has been found. Designing a garden for restaurants. Different methods are utilised to collect information regarding the project. All the data is collected and documented without disregarding any information. [Brown, V. (2023)]

In this chapter, the group explores in more depth the competitors, the users, and possible factors that might interfere with the current routine in a restaurant.

Interviews with restaurants

In order to understand why restaurants want to have their own gardens and gather information to design a product that they could use, interviews with restaurants are performed. The first part of the interview consists on understanding their opinions on the current system. The second half of the interview consists on undertanding their needs and wishes for their own garden All the information gathered can be found in Appendix 05:

Current system

- Limited offer: Restaurants can't always get what they want or need, as current suppliers don't always have the same products available (this is due to variable demand and a weather dependent plantation).
- Not always fresh, as it needs to be stored and then transported on demand. It does not get fresher than harvesting it directly in the restaurant.
- Very convenient since all they have to do is order online

Requirements if they had their own garden

Name	Quantity per unit	Unit	Price per unit	Quantity ordered	Total price	
Microgreens						kr 799
Karse	500	gr	26,4	4	kr 106	
Aerte skuld	500	gr	99,79	4	kr 399	
Affila	1000	gr	132	2	kr 264	
China rose	100	gr	15,18	2	kr 30	
Salad					kr 0	kr 388
Spinach	500	gr	46,2	4	kr 185	
Mizuna	500	gr	52,8	1	kr 53	
lollo bionda	1	pcs	12,54	4	kr 50	
lollo rosa	1	pcs	12,54	4	kr 50	
Frillice	1	pcs	12,54	4	kr 50	
Roots					kr 0	kr 551
Selleri	1	pcs	11,14	3	kr 33	
Porrer	1	pcs	23,1	2,5	kr 58	
Asparragus	500	gr	34,32	2	kr 69	
Potatoes	7000	gr	101,64	1	kr 102	
Radish	121	gr	4,95	4	kr 20	
Escalion	180	gr	6,02	28	kr 167	
Danish onion	10000	gr	89,1	1	kr 89	
Carrots	5000	gr	13,85	1	kr 14	
Herbs						kr 317
Estragon	50	gr	14,19	3	kr 43	
Dill	150	gr	16,24	3	kr 49	
Rosemary	50	gr	15	3	kr 45	
Mllise	50	gr	19,8	1	kr 20	
Koriander	50	gr	13,04	3	kr 39	
kOrvel	50	gr	14,19	3	kr 43	
Persille	200	gr	15,84	5	kr 79	
Fruit						kr 164
Agurk	1	pcs	5,84	2	kr 12	
Chili	30	gr	1,98	30	kr 59	
Citron	1	pcs	3,1	30	kr 93	
					Total	
					kr 2.220	

Ill.32. Chart with restaurant cuantities and prics

The table on the left approximately represents the amount of greens Skagen Fiskerestaurant orders a week. The concept should provide at least the same amount.

It should be automatic since restaurants open an average of five days a week.

Multiple people should be able to take care of it (personnel varies from day to day).

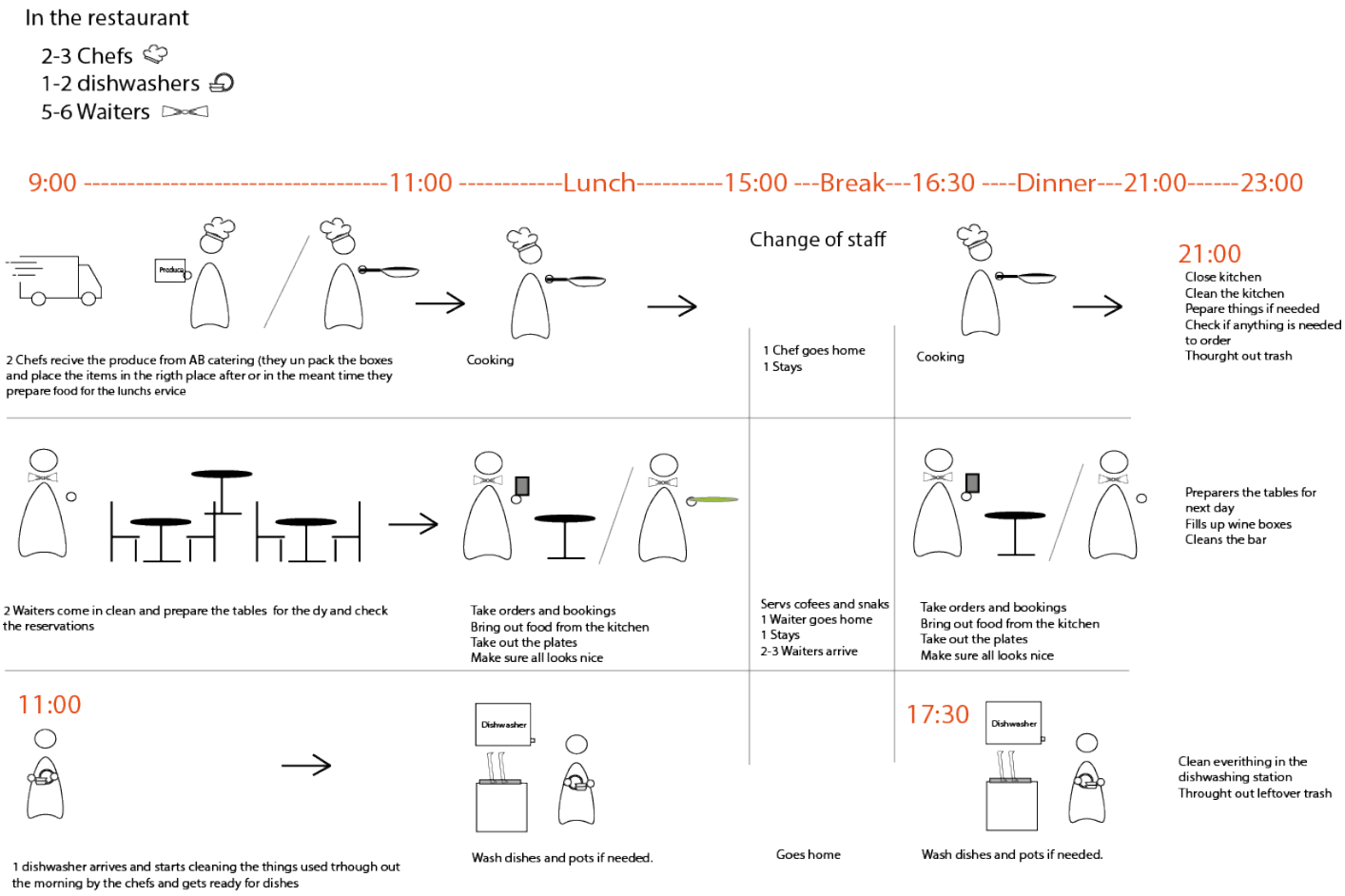
Easy to clean.

They only want to spend one to two hours a week on it.

Should meet the law requirements (about dirt, bugs, smell, etc.)

A DAY IN A RESTAURANT

During the shadowing day and through casual conversations with the chefs, it is possible to reconstruct what a day in a restaurant looks like. This is done to understand how and where the product would affect the current workflow. This Illustration is confirmed by a Skagen Fiskerestaurant employee.



Ill.33.daily rutine of personal in a restaurant

Throughout the day, the service personnel changes and varies in numbers.

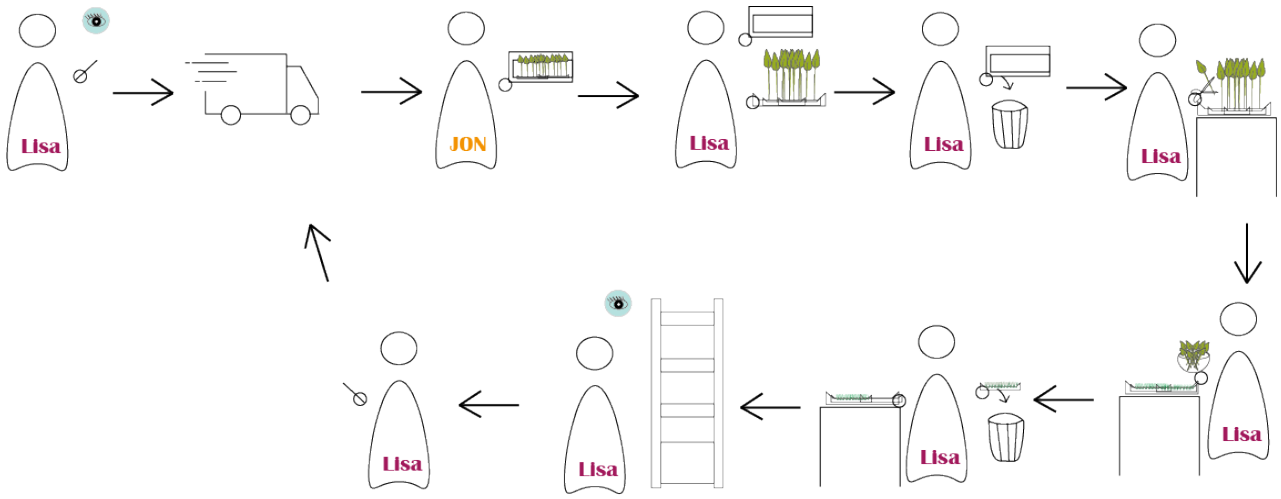
Implementing the concept as a part of the morning routine while the chefs prepare the lunch service might be the best option.

Repeated requirement: Multiple people should be able to take care of it since the personnel varies throughout the day.

Ordering process

As a part of the interview with the chef from Skagen Fiskerestaurant, he explains to the group what the ordering process for food looks like. Every night, the main chef checks what has been used and what is needed for the next day. These quantities vary depending on the day and reservations. He writes it down and then sits infront of the tablet to order it in the AB catering app. Sometimes the things he needs are not available so he needs to think of an alternative.

When it arrives to the restaurant it comes in cardboard boxes with the different items inside. Some of the items come also in bags, which need to be opened and sorted in to Condi boxes and place on the fridge. Condi boxes are small plastic boxes used to sort the food that is prepared before the service.

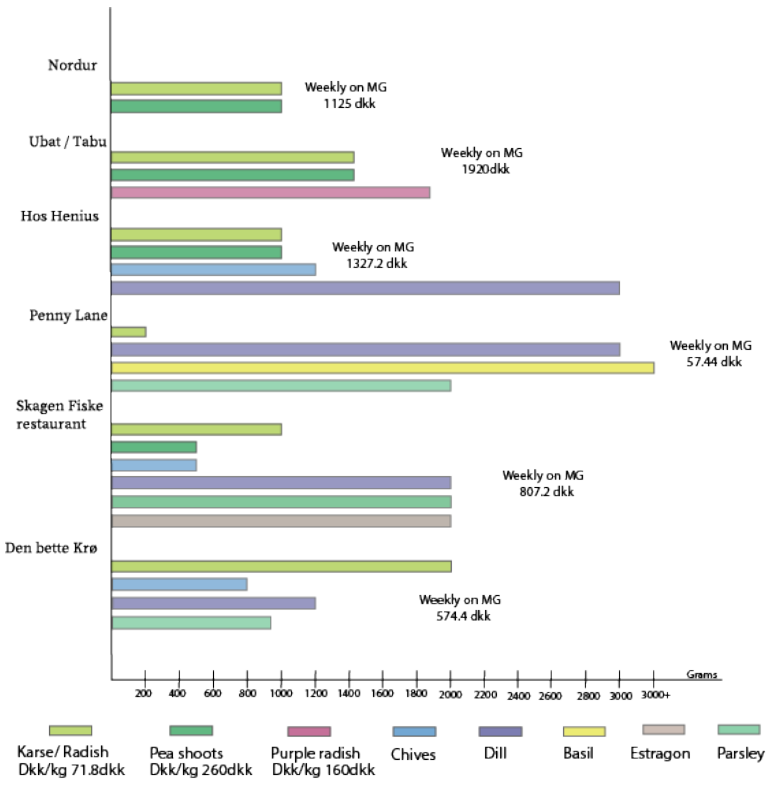


Ill.34. current process of microgreens in a restaurant

To get a better idea of the amounts of greens other restaurants use, and not only the amounts Skagen Fiskerestaurant uses, the group interviewed other chefs in Aalborg area. The aim of these interviews is to collect data regarding amounts and prices of the greens that they use.

Illustration 35 shows the data collected during the interviews. Some information is only estimates since the chefs did not know the precise number since it varies from week to week.

As seen, the numbers that were obtained were only for microgreens and leafy greens. In general, the microgreen data is similar to that of Skagen Fiskerestaurants. However, the data for the herbs really depends on the restaurant.



Ill.35. Quantity graphic of produce used

Market research

To obtain information about the current market for companies that provide greens for restaurants, market research is made. This market research consists of a mix of information obtained through phone calls and desktop research. In addition, the market research will aid the group on how to provide a concept that will differentiate from the rest of the competitors and improve the vegetable supply for restaurants.

Current system (AB catering): Food distributor servicing all regions of Denmark. They provide to a wide range of kitchens from small-scale vendors to large-scale kitchens. They mostly import their supply from other countries were the production is bigger and therefore cheaper.
AB catering tries to reuse as much packaging as they can from the boxes they get from their suppliers. They are also currently working on developing a system so all the one time use boxes disappear and everyboy uses "Green boxes", a foldable plastic box. This change is driven by a possible new that could be enforced in the coming years.

Ill.36. Farmers market

Mana farms: German start-up, Newly funded company (2021) specializing in sustainable agriculture as indoor farming solutions in restaurants and other public use areas. They focus on vertical farming technologies and offer customized solutions for efficient and year-round crop production. By utilizing advanced technologies like hydroponic systems, they create controlled environments to optimize plant growth and resource utilization.

Restaurant garden: Some restaurant have their own garden were they grow their own vegetable, they really enjoy it and are proud of it, but it only works few months of the year.

Local farmers:For restaurants were local production is one of their core values, they make partnerships with farmers in the area, tho thye are not 100% relyable.

Hydroponic farmers
These are some of the different suppliers of greens that some of the restaurant uses, they all have different pros and cons but mainly the restaurants don't like using this solution as they will need to order from more than one place and sometimes is not so much price difference.

Microgront: Is a company dedicated to the cultivation and distribution of high-quality microgreens. They specialize in growing microgreens using hydroponic systems. Suplaying to customers, including restaurants, hotels, and individual consumers.

Baby leafs: Is a supplier of leafy greens including baby spinach, baby kale, and mixed baby greens. They specialize in providing fresh, pesticide-free greens that are harvested In the traditional cultivation method in all around Europe

Nabo farms: Is a Copenhagen provider of microgreens and edible flowers. Their microgreens and edible flowers are grown indoors, allowing for year-round production and consistent supply. They take sustainability serious, by making their daily delivery by bike and using directly Condi boxes as packaging.

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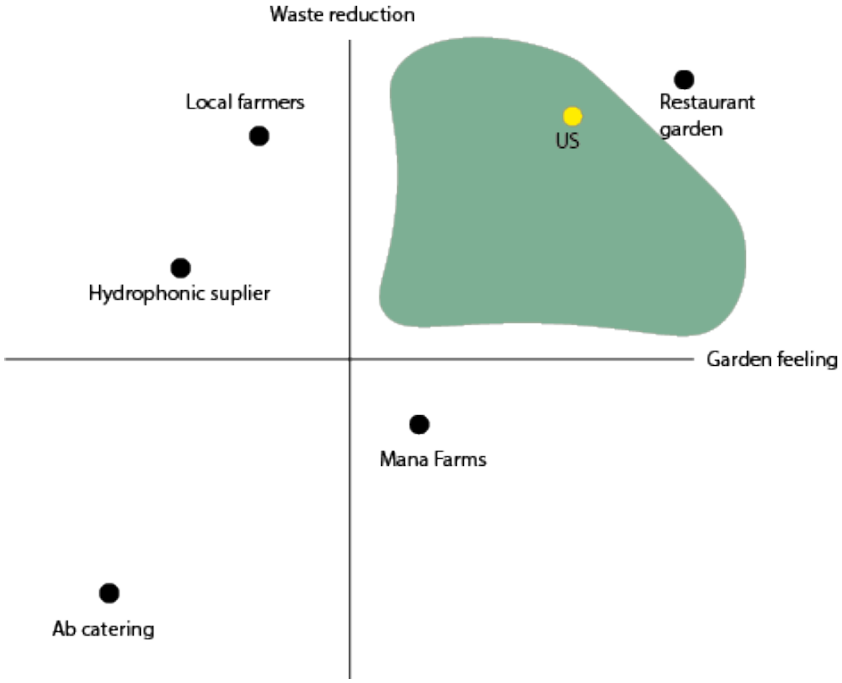
FINDING THE GAP

With the information found from the market research, a market positioning graph is drawn. The idea with this is to help the group find a gap in the market where a new product could be introduced. The interviews performed so far give the group the insight that, even tough the garden should be automated, they still want to have the feeling of gardening. Because of this, on one axis, the gardening feeling is added, and on the other axis, waste reduction is added.



Ill.37. Market positioning graphic

In the horizontal direction of the graph, the different options are organised from least gardening feeling, on the left, to most gardening feeling, on the right. On the vertical axis the options are organised from least waste reducing at the bottom, to most waste reducing at the top.

The gap is found on the top right quadrant where, the main competition would be the classic outdoor garden. The aim is to give the restaurants that gardening feeling while still maintaining the automatic system so that on the days that the restaurant is closed, the plants will still be taken care of.

The classic outdoor garden does not produce crops all year round unless it is in a greenhouse.

Not all restaurants have outdoor space for a garden.

Collaboration

Through an AAU student from the Robotics Bachelor, it is discovered that a start-up company has proposed a student project in the electronics department to study how microgreens grow under different conditions.

Because of the similarities between the projects, the group reached out to the start-up to collaborate with them and obtain information.

The start-up has a prototype in the testing phase. This prototype is placed in a restaurant/ Cafe in Skorping called Bagtanker.

Bagtanker

Bagtanker is a local establishment that specializes in home-made sourdough bread and a variety of culinary offerings. Located within the Skørping Sports Centre, they prioritise quality by preparing all their food in-house using organic ingredients whenever possible. With a commitment to sustainability, Bagtanker continuously strives to find innovative ways to promote environmental solutions. Their spacious restaurant can accommodate over 30 guests and provides amenities such as convenient parking and a children's playroom. Bagtanker offers a delightful dining experience that combines exceptional food with a focus on sustainability. [Bagtanker, (Unknown)]

During the interview with Teis, (the owner) and Heidi (worker mostly in charge of the garden) several important points and takeaways were discussed. Here are the key highlights:

-Experience with the prototype: When the group visited the restaurant, the prototype was closed down. The reason for this is that the use of soil had attracted flies.

-Lighting Concerns: The restaurant aims to find a lighting solution that creates the right ambiance without giving the impression of growing illegal substances.

-Time and Effort: Because of the use of soil, the seeding is done outside. The reason for this is that filling up the trays with soil inside is very messy.

-Preferred Plants: Peas shoots are the preferred option for cultivation, while herbs are occasionally grown. Sunflowers seed have proven to be messy and short-lived if not harvested promptly. The restaurant is interested in incorporating a variety of options, including flowers, cabbage,and leafy greens.

-Customer Perception: Customers appreciate the use of self-grown produce, considering it to have better taste and quality. They value the sustainability aspect of locally sourced ingredients.

Ill.38. Flies in Bagtanker

This activity provided the group important insights that are to be considered during the concept development phase.

Soil attracts flies which annoy customers in the restaurant.

The lights have to be chosen carefully

The process should be clean and quick

Target group

To narrow down the target group, a thorough study involving interviews and visits to various types of restaurants is performed. For a detailed version of this study please see Appendix 06.

Through this comprehensive research, the group gains valuable insights into the restaurant environment in Aalborg. It becomes evident that fast food chain restaurants, with their emphasis on low prices rather than food quality, does not align with the product's target market and ambitions.

Fine dining restaurants emerge as a potentially well-fitting category, as they have the potential to attract more clients by incorporating the product into the overall dining experience, and thereby enhancing the freshness and quality of their produce.

Eco-friendly and vegetarian restaurants also show compatibility with the concept. However, it is important to note that achieving complete self-sufficiency in such establishments (since they need larger amounts of greens) would require significant space.

The group envisions the ideal fit for the product in a restaurant that prioritises freshness, self-sufficiency, and ecological aspects of food. Vertical gardens would serve as a prominent decorative element in such establishments. The restaurants in Aalborg that fit with the ideal vision of target, are higher end restaurants like Skagen Fiskerestaurant, Applause, and Ubat amongst others.

Ill.39. Brd. Price CPH

Ill.40. Ubat restaurant

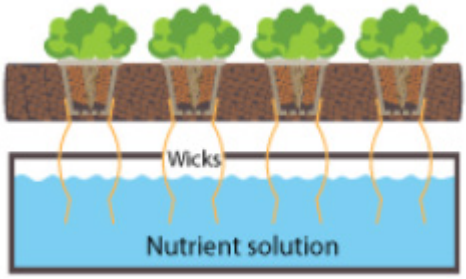
Ill.41. Restaurant Applaus

Ill.42. Restaurant Fusion

Growing method

So far, the discovery phase has been user centered. Finding insights and requirements from their perspective. From now, the discovery phase will be for the technical aspects required for the vertical garden. The aim of this specific section is to find out how the watering system behind the vertical garden should work. One of the requirements found during the interviews was that the system should be automatic.

Wicking Systems:

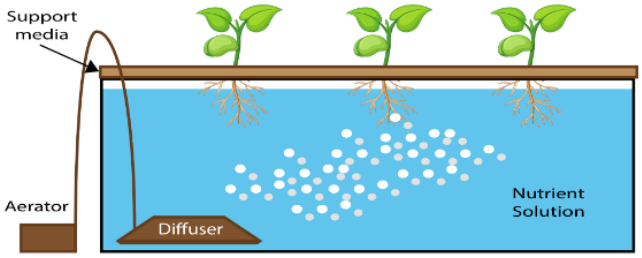


Ill.43. Wicking systems

Represents the simplest form of hydroponic systems, requiring no water or air pumps. In these systems, the wick absorbs the nutrient-rich water and provides it to the plants. This system does not work well for large greens. It is also not considered to be a good solution for vertical gardens. [Bulla, A. (2022)]

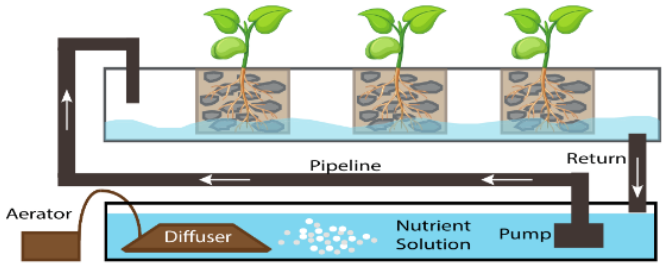
Deep Water Culture (DWC)

Unilike the wicking systems, in the deep water culture, the plants receive the nutrient-rich water by having their roots always submerged in the solution. In this case, an air pump is needed to provide oxygen to the roots. Bceause of the space required for these systems, they are also not recommended for vertical gardens. [Bulla, A. (2022)]



Ill.44. DWC system. [Velazquez-Gonzalez, R. et al.(2022)]

Nutrient Film Technique (NFT) Systems:

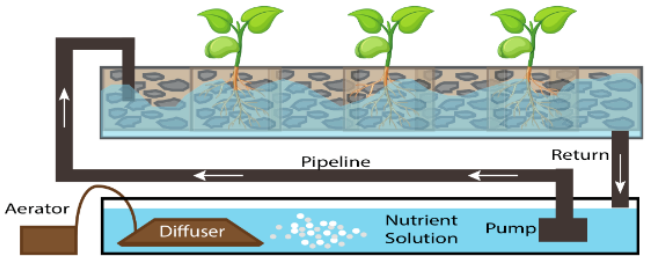


Ill.45. NFT system. [Velazquez-Gonzalez, R. et al.(2022)]

The nutrient film technique consists of prividing a thin layer of nutrient solution to the roots of the plants. Unlike the deep water culture, the plants are not always submerged in water. These are suspended on an inlcine surface so that the solution recirculate back into the water tank. [Bulla, A. (2022)]

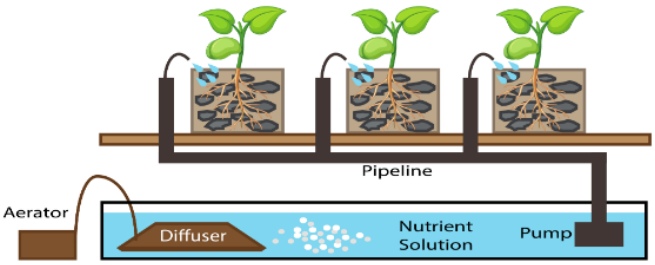
Ebb and Flow Systems:

Ebb and Flow systems consist of flooding the plants for a certain period of time and then draining them again. To do this a reversible water pump is used normally used. Otherwise the return pipe is placed at a ceratin hight so that water can only reach a maximum level. Compared to the rest of the systems, this one is more complex to set up. [Bulla, A. (2022)]



Ill.46. Ebb and flow systems [Velazquez-Gonzalez, R. et al.(2022)]

Drip Systems:



Ill.47. Drip systems [Velazquez-Gonzalez, R. et al.(2022)]

In this system, all plants are watered individually through a pipeline system. A timer is used to water the plants. Because of the the amount of pipes and hoses, leakage is common [Bulla, A. (2022)]. Probably not a good fit for restaurant use.

Interviews with competitors

To try to understand in further detail and with a physical set-up, vertical gardening companies were contact to try to arrange an interview or a physical meeting. Unofrtunately, no vertical gardening companies were able to cooperate with the group.

Because of this, the group resorted to finding a hobby vertical gardener and is how Mads was contacted. He designs vertical gardens for hotel lobbies and has now been working with vertical gardens for over a year. A meeting was not arranged but a phone interview was planned and the group received pictures and videos of his set-up. In his design, he uses drip systems and utilises only one water pump for all the different levels.

Ill.48. Hobby gardener setup 1

Ill.49. Hobby gardener setup 2

As long as the pump can lift water to the right hight, it will be able to water all levels.

Does not use any external sensors other than a humidity sensor for the soil.

Proper ventilation is a must to avoid mould and pests.

Types of vegetables

During the restaurant interviews, different types of vegetables were found. In this section, a classification of these is made and further desktop research is done to gather information regarding their growing time in hydroponic systems. The aim of this research is to narrow down the types of greens that the concept should be designed for. The information presented below is based on Appendix 07:

Ill.50. Leafy greens

Leafy greens (3 weeks to grow hydroponically) Eg.kale, collard greens and spinach.

Ill.51. Microgreens

Microgreens (8-12 days) Eg. watercress, radish and mustard microgreens

Ill.52. cruciferous

Cruciferous: (100-150 days) Eg. cabbage, broccoli, cauliflower, etc.

Ill.53. Root vegetables

Root: (30-100 days) Eg. potatoes, carrots and onions among many others

Ill.54. Asparagus

Edible plant stem: (+140 days) Eg. asparagus, celery and rhubarb.

Ill.55. Herbs

Herbs: (60-270 days, continuous harvesting) Eg.dill, basil, cilantro and rosemary

This activity provides the group the necessary information to disregard some of the vegetable types. Providing the restaurants a vertical garden that would grow vegetables for them to be ready in over two months is not of interest to them. Furthermore, some vegetable types, like root vegetables, are not well suited for hydroponics. Because of this, from now on the project will focus on growing leafy greens and microgreens.

The next step in the process is to figure out what the ideal growing conditions for these greens are.

Solution for microgreens and leafy greens.

Category needs

The project now focuses on developing a concept to grow microgreens and leafy greens for restaurants. To understand what the ideal growing conditions are for these greens, desktop research is done. This conditions will be taken into account in the future design of the concept.

Leafy greens:

-Light: Most of the leafy greens require a approximately 16 hours of light since its mostly leaves anf not to much of growing tall. (Jagdish, 2020)
-Air temperature: 21-24°C
-Air humidity :40 - 60 percent
-Seeds: Best to buy organic
-Water balanced pH (usually around 6 to 6.5), needs to be humid but not in constant contact with water.
-Growing medium: Eg.Coconut coir, hemp plugs, this will give the roots something to grab onto and help them stand upright.
-Ventilation: Fans, Stagnant air can increase the chances of fungus or mold growing. Especially in a large moist area. Keeping air circulating is important to the health of the plants.(Nadaraja, 2022)

Ill.56. Hidroponic letuce

Microgreens:

-Light: most microgreens need about 12 hours of light and 12 hours of darkness in order to thrive. T5 fluorescent lamps are usually preferred by microgreens growers, but regular T8 lights will work as well and are normally cheaper.
-Air temperature: 21-24°C
-Microgreen seeds: It's best to buy organic seeds that are bred specifically for growing microgreens.
-Water balanced pH (usually around 6 to 6.5), needs to be humid but not in constant contact with water.
-Growing medium: Eg.Coconut coir, hemp mats, this will give the roots of the microgreens something to grab onto and help them stand upright.
-Ventilation: Fans, Stagnant air can increase the chances of fungus or mold growing. Especially in a large moist area. Keeping air circulating is important to the health of the microgreens.(Nadaraja, 2022)

Ill.57. Microgreens

In addition to this growing conditions for each type, a more general parameter is found with the colour of the lights: In the light parameter the most important factor is the wave length and the mix ratio of the different colours. Plants grow best when they have all colours of light. They want mostly red and blue. The ideal ratio is somewhere around 5:1 red to blue.This means white light, which includes all of the colours. Since plants do need more red and blue than other colours, grow lights that supplement all white diodes with additional red and blue diodes are ideal.(Microgreens Corner, 2021)

Looking at the information found from the desktop research and comparing it to the information obtained from the vertical gardener hobbiest, it is necessary to make a differentiation between nice to have and need to have so that the greens can thrive.

The greens need for light between 12 and 16 hours a day.

The air temperature should be between 21-24°C and the air humidity between 40-60%.

Water balnaced pH of around 6 to 6.5.

Full light spectrum is ideal for both types of greens.

5

DEFINE 2.0

In this chapter, the design brief is updated with the new data gathered in the second discover chapter. In this case, during the second discover phase, the types of greens that the project should focus on was already narrowed down. During this chapter, any further decisions regarding the problem space of the project will take place.

#	Insigth	Source	Working principle
1	Restaurants wish to have their own garden	Interviews with cheffs	Garden feeling
2	The chefs lack of space, time and knowledge requires some further investigation to come up with a concept	Interviews with cheffs	User intuitive
3	Throughout the day, the service personnel changes and varies in numbers.	Interviews with cheffs	Multi-user
4	mplementing the concept as a part of the morning routine while the chefs prepare the lunch service might be the best option.	Interviews with cheffs	Implemented in the rutine
5	The classic outdoor garden does not produce crops all year round unless it is in a greenhouse.	Research	
6	Not all restaurants have outdoor space for a garden.	Restaurant visits	Needs to be indoor
7	Soil attracts flies which annoy customers in the restaurant.	Bagtanker	No soil
8	Purple UV ligths, are asociated with growing ilegal substances	Interviews	Ligths need to be chosen carefully
9	Is a Restaurant so the place should always be clean	Interviews	Esay to mintain and clean (Dishwasher)
10	As long as the pump can lift water to the right hight, it will be able to water all levels.	Competitors	Pump should get to the water to height

Design Brief

The first design brief stated that the aim of the project was to reduce waste related to the supply chain and manufacturing of the packging for vegetables. After further research, the design brief has further evolved. The new aim for the project is to completely eliminate the waste from the packaging for vegetables by providing the restaurants with a product they are more interested in, their own garden.

Vision

The vision for the project is to completely eliminate waste from the packaging for vegetables.

Mission

Provide restaurants with their own garden so that they can be self-sufficient for microgreens and leafy greens.

Market

Having explored the different target groups for the project, the aim is to provide a product for high end restaurants like Skagen Fiskerestaurant or Applause.

Requirerments

Well-defined demands:

-Should provide approximatelly 6 kg of micogreens and 4 kg of leafy greens a week.
-Should only require 1-2 hours a week to maintain it.
-The greens need like between 12 and 16 hours a day.
-The air temperature should be between 21-24°C and the air humidity between 40-60%.
-Water balnaced pH of around 6 to 6.5.
-Full light spectrum is ideal for both types of greens.

Ill-defined demands:

-It should be automatic
-Multiple people should be able to take care of it
-Easy to clean
-Proper ventilation needed to avoid mould and pests

6

DEVELOP 2.0

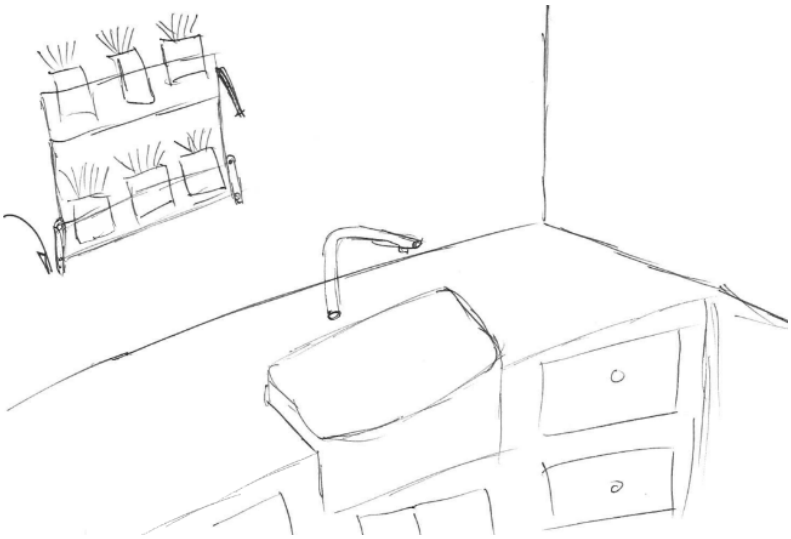
During this chapter, the concept development takes place. Different methods such as sketching, quick and dirty prototyping, try-it-yourself, amongst others are used to gather information that aid in the evolution of the concept. The aim is to explore possible solutions in key interaction points to choose the most suited option.

Sketching and clustering

To begin the second development phase, the group decides to once again utilise the lean start-up method to quickly get some ideas out onto the table for further iterations after analysing them. In Appendix 08 the full analysis of the sketches and feedback from two chefs can be found.

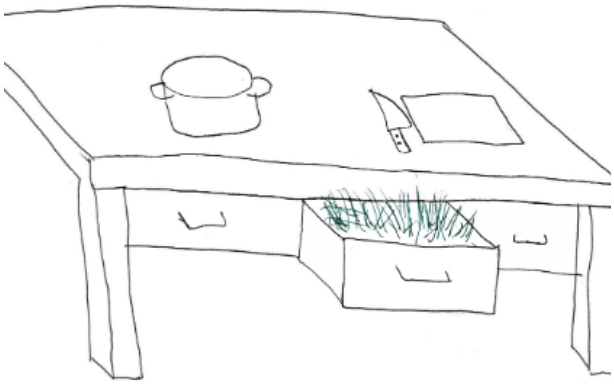
After the first few sketches, three clear directions were being drawn. To organise the process, it was decided to quickly cluster these first few sketched into, indoor garden in the kicthen, indoor garden in the dining area, and outdoor garden so that the following rounds could use these themes.

Indoor garden in the kitchen



Ill.58. Sketch vertical shelf for the kitchen

Ill.59. Sketch greenhouse for the kitchen

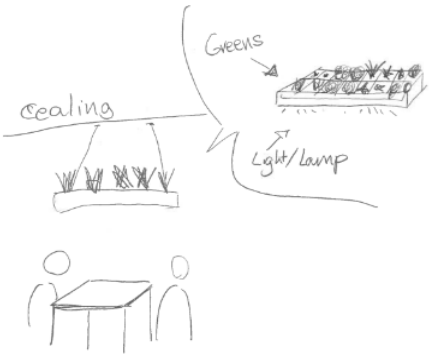


Ill.60. Sketch green growing drawer for the kitchen

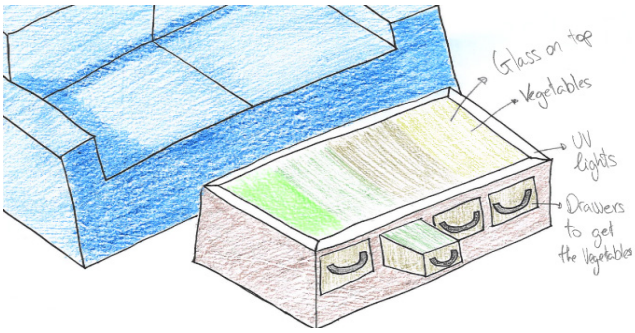
The sketches in "indoor garden in the kitchen" theme, try to utilise space around the walls of the kitchen where the vertical garden could be installed. Other options within this theeme are having a small kitchen greenhouse or utilising empty drawers to grow greens.

Chefs feedback and the teams:
- The main feedback for this round is that the kitchen is a highly funcitonal space and not every kicthen will have space for such a product.
- Worried about how big it would be if it has provide enough greens for the restaurant to be self-sufficient.
- Since the greens are hanging on the walls, the are worried that fumes from cleaning and cooking will affect the taste and health of these.

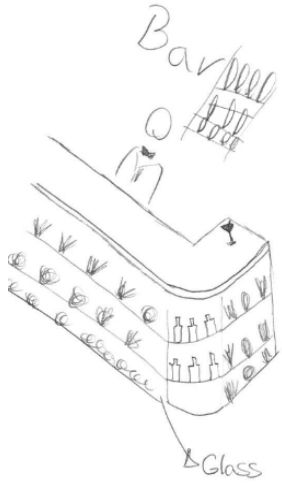
Indoor garden in the dining area



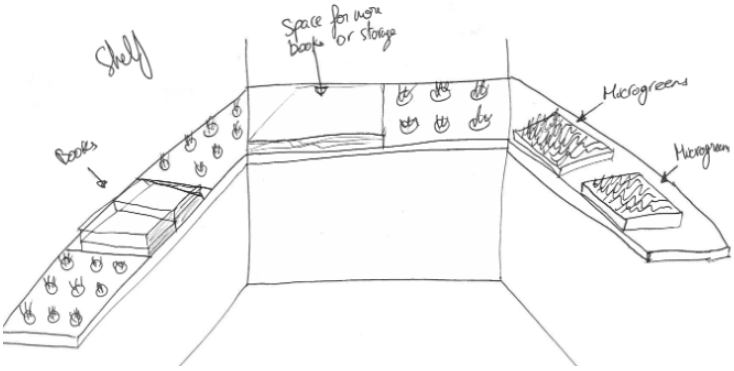
Ill.61. Sketch lamp with a top garden



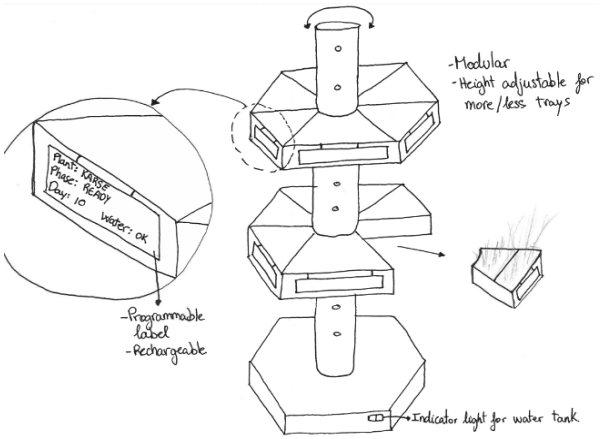
Ill.62. Sketch green growing table



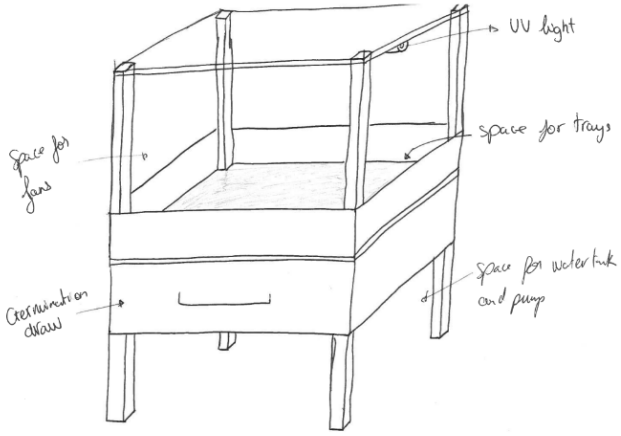
Ill.63. Sketch bar showcasing and growing greens



Ill.64. Sketch selves around the restaurant to decorate and grow greens



Ill.65. Sketch modular green tower

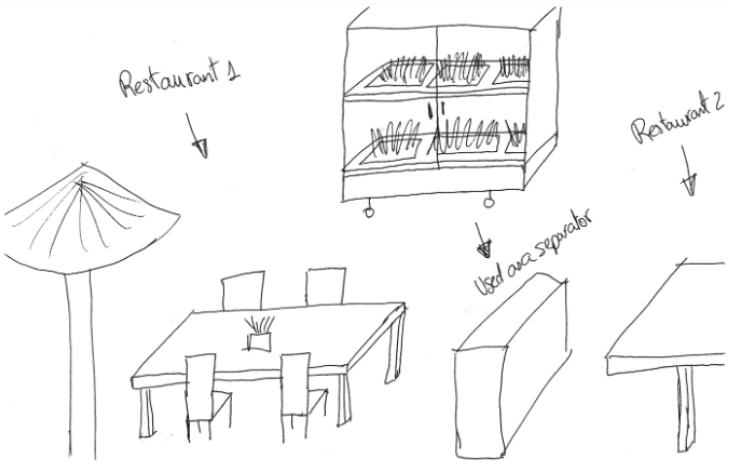


Ill.66. Sketch Shelf with drower for green growing

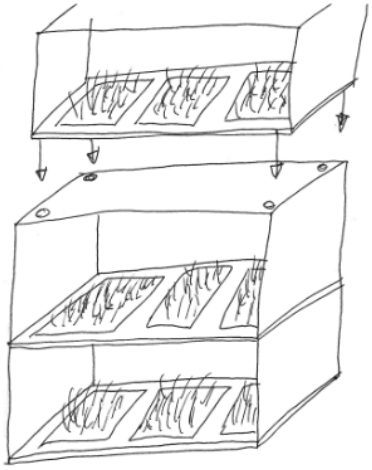
The sketches in "indoor garden in the dining area" theme, use a wide veriety of space and different opportunities, ranging from a cupboard looking concept to a table that contains greens inside. Some options like shelves were also utilised in the kitches space.

Chefs feedback and the teams:
- The main feedback for this round is that it could look really attractive in the dining area and seeing the chef go out to harvest during dinner service.
- Do not like the "weird" designs since they would not fit in all dining areas and are worried about the size of the product.

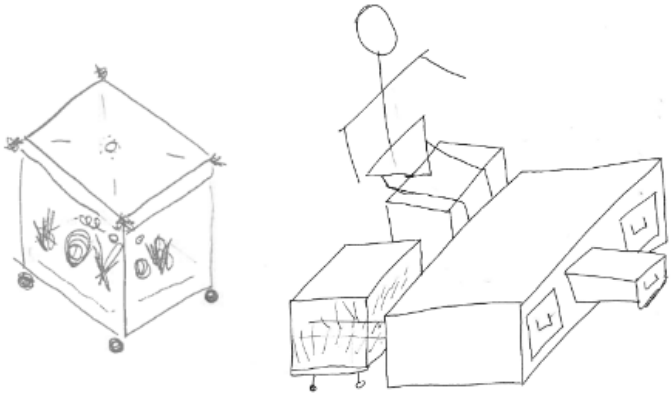
Outdoor garden area



Ill.67. Sketch table separator for the terrace



Ill.68. Sketch modular table fro green growing



Ill.69. Sketch green house seat

Ill.70 . Sketch futuristic look green tower

The sketches in "outdoor garden area" theme, try to utilise the space outdoors where some restaurants have some tables during summer periods. One concept presents the opportunity to use the vertical garden as a table separator or restaurant separator. Another concept presents the garden as a chair for outdoor use.

Chefs feedback and the teams:
- The main feedback for this round is that if the product should be placed outdoors, it should be movable and have no cables running on the floor because the waiters could trip.
- Not all restaurants have space outdoors and the outdoor area is only used during summer. This means that the market for the product would be very limited.

Conclusion from this activity

The feedback from the chefs and the groups own analysis on the first sketching round for vertical gardens, leads to the group narrowing down the solution space to indoor gardening for the dining area. The kitchen area is ruled out because of the general lack of space in highly functional kitchen. The outdoor area is ruled out because of the noticeably smaller market since the restaurants are limited to ones with outdoor area.

The chef harvesting during dinner service could attract clientele.

The look of the product should match the restaurants look.

Prototype for restaurant

As mentioned previously, the vertical garden should be placed in the dining area of the restaurant. Because of the time pressure under which the project is made, it is decided to make a functional prototype to give to a restaurant. The reason for making the prototype so early on is because of the time span that it takes to grow the greens. The aim of the prototype is to gather information regarding the interaction with it and to gather further insights on the looks and the customers reaction.

Using the information learnt from the discovery phase, lights, fans, and an automatic watering system are chosen for the prototype. Furthermore, a growing medium is needed and the seeding scenario has to be developed. At this point, the idea is that the chefs have the prototype in the dining area, harvest the greens when necessary, and start growing some more.

The prototype is made for microgreens since they only take 10 days until they can be harvested in comparison to the 30 days it takes for leafy greens. It is handed out to Nordur, a 100% plant-based restaurant in Aalborg. The idea is to leave it there for three weeks.

Choosing growing medium

Ill.71. Hemp mat

In Appendix 09, research is done on the different growing mediums available. A comparison is also made between them where different factors are taken into account:

- Organic/ biodegradable (because the aim vision of reducing waste in restaurants)

- Inexpensive and easy to obtain (some options explored in the Appendix 09 have to be ordered from America so not CO2e friendly or efficient)

- Areation and drainage (so that the roots of the plants can breathe and exchange air)

- Moisture retention (so that the roots can contantly feed)

- Sterile (prevents pests and mould)

These factors narrowed down the possibilities to 3, hemp mats, coco coir mats and Biostrate. Out of these options, the easiest to obtain was hemp mats and therefore was used for the prototype.

Ill.72. Biostrate mat

Ill.73. Coco coir mat

Seeding scenario

To determine the most comfortable way to place the seeds on the growing medium, different options are investigated. These options are then tested. During the testing, the group realises that for the leafy greens, the process of sprinckling seeds is not necessary since only one seed is needed.

Three diferent tools are tested to place the seeds on the pad.

Ill.74. Seed shaker

Shaker:

This method of seeding is straightforward. The shaker is filled and then the seeds are sprinckled on the medium. Here the shaker should spread out the seeds.

Envelope:

This method of seeding requires the user to place some seeds in an envelope and then shake the seeds out. This method is a bit harder and requires practice so that the seeds are spread out.

Ill.75. Seed envelope

Ill.76. Seed in hand

Hands:

Spreading the seeds with the hands gives a feeling more like gardening, but like the previous method, it requires practice. It also requires a separate tool to measure the ammount of seeds.

Measuring spoons:

The method of measuring spoons works quite well as is easy to sprinkle and measures exaclty how much has been poored. Seeds have different sizes so it requires different size spoons.

Ill.77. Seeding with measuring spoon

The most fitting method for seeding are the measuring spoons, therefore a measuring spoon set will be provided per client.

Wtih the seeding method chosen, the group now tests out the seeding scenario to act out the hole process.

The seeding process acted out is the one for microgreens since it has more steps than the leafy green seeding scenario.

1) Soak the hemp mat

2)Make sure the mat has absorbed the water

3) let the matt drain a bit

4)Place the mat in the microgreen tray

5) Fill up a table spoon

6)Spread them around the matt as even as possible

7) With the water spray, spray the seeds

8)Spray the surface of the weigth

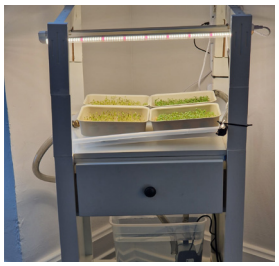
9) Place the weigth on top of the seeds

10) Place the trays in the germination drawer

11) Let them stay there for 3 days

12) After the 3 days open the drawer and take the weight off

13)Place the trays in the watering tray under the ligtht



14) Make sure the light and all electronics are working fine

15) Let them sit there for 7 days

16) After the 7 days the micro greens should look green

17) Take a clean sharp knife and cut one cm over the pad

18) Ready to use in delicious dishes

19) If not used and they are already harvested, they can stay up to four days in the fridge.

Ill.78. Microgreen seeding process

Leafy greens

When seeding the leafy greens some steps change from the microgrens process. Steps 1-3 are the same. Then steps 4.A to 6.A are used (seen below). Aagin if the greens are harvested and not used, they can be kept in the fridge for a few days.

4.A) Place the wet medium in the pot

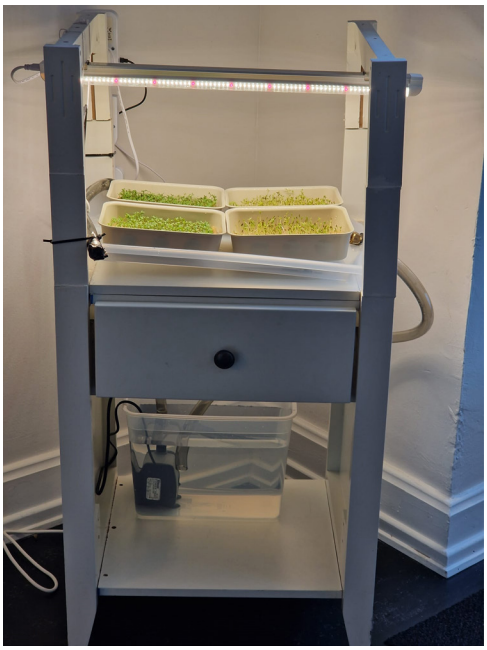
5.A) Place the pot into its try soket

6.A) Wait for 21 days

Ill.79. Leafy greens seeding process

Testing the prototype in real life

The group was able to test for three weeks the prototype in Nordur, a vegetarian restaurant in Aalborg, this restaurant is quite special as they try to keep all their produce locally sourced and be as most zero waste as possible. The prototype was brougth to them and intructions were given to the main contact person that was goint to take care of it. The group passed by the restaurant every week to see if they needed anything. The prototype was placed in the dinnig area and brougth the attention of many costumers.



Ill.80. Prototype at Nordur

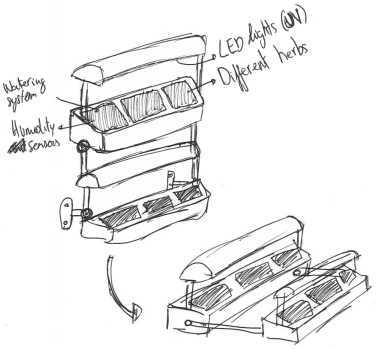
Feedback and observations

-They hadnt filled up the water tank
-They didnt really know when the harvesting or germination was ready
-The clients were very intrigued by the prototype and it sparked a lot of conversation with the waiters
-Positive feedback from the clients
-They liked the concept but, it needs to be self-suficient
-Requires initial learning time
-They were impressed that it did not made much noise.

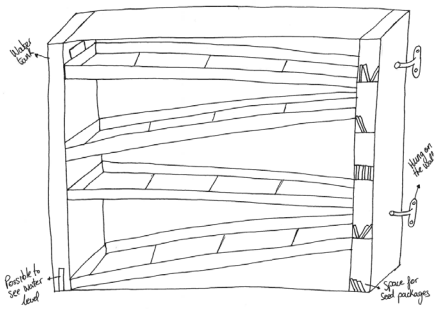
More sketch using requirerments

With the evaluation of the first sketching round in mind, a second round of sketches is done to iterate and develop the concepts further. The three concepts chosen are the wall hanging concept, the cupboard concept, and, because of the positive feedback the modular concept received, it was incorporated into an indoor concept.

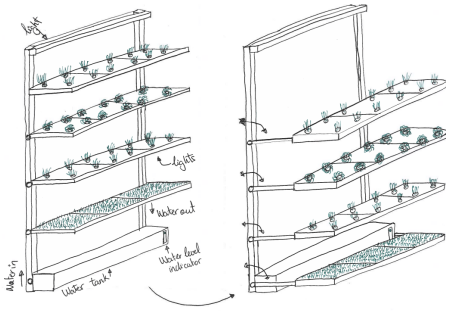
Wall hanging concept



Ill.81. Sketch wall hanging concept 1

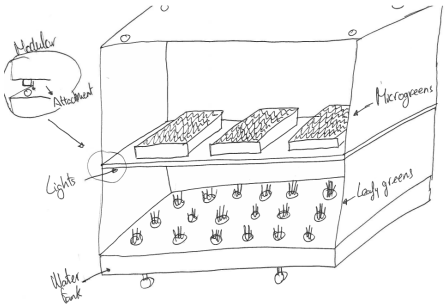


Ill.82. Sketch wall hanging concept 2

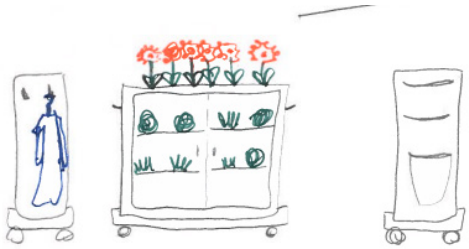


Ill.83. Sketch wall hanging concept 3

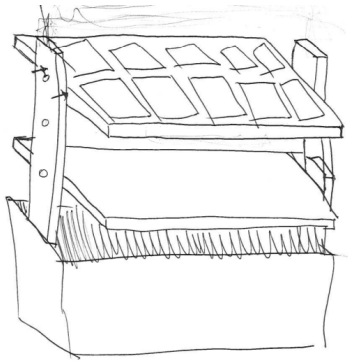
Modular concept



Ill.84. Sketch modular concept 1

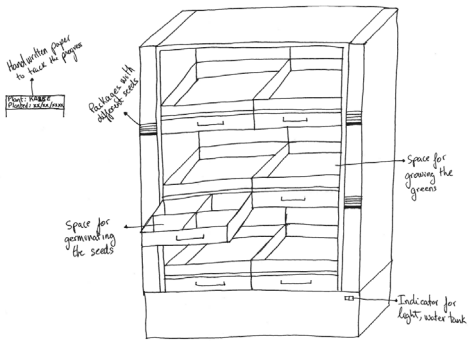


Ill.85. Sketch modular concept 2



Ill.86. Sketch Modular concept 3

Cupboard concept



Ill.87. Sketch cupboard concept 1

The sketches are presented to two different chefs to gain feedback. The category that the chefs are most interested in is the modular concept. The reason for this is that neither chef believes that they would make a huge initial investment on a product like this. Being able to incrementally incorporate it into the restaurant is a big plus. It also has the highest flexibility in terms of where it can be placed in the restaurant.

The product needs to be able to make the restaurant self-suficient as otherwise they would not be interested.

Development of product size and interactions

The following few pages present how different key aspects of the concept are developed. Some of them are developed simultaneously but it is presented as a linear process.

Size development

To define the size of the product, the group set out to different high-end restaurants to measure how much space there is available in the current restaurant. Before going out to the restaurants, an assumption is made:

Restaurants currently try to utilise space efficiently meaning that decorations or tables are used to create a good atmosphere in the restaurant. Because of this, it is believed that it will be hard to find a suitable space. However, the possibility of rearranging some tables or decorations to fit a product is to be discussed with the waiters.

Out in the restaurants, this assumption is verified making it hard to find some restaurants that could potentially have enough space for the product without having to move anything. In general, the waiters said that there would be a possibility of rearranging the furniture since the vertical garden being installed would be practical and functional instead of simply another decorative piece.

Ill.88. Measuring spots in restaurants

Ill.89. Possible placing spot in Dejavú

Ill.90. Possible placing spot in Skagen fiskerestaurant

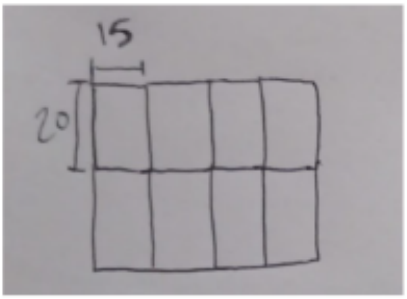
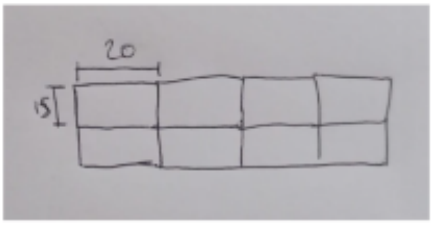
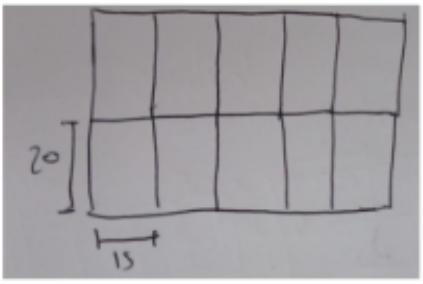
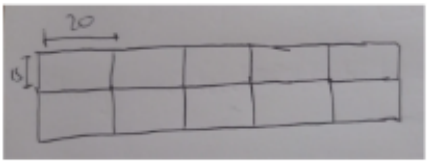
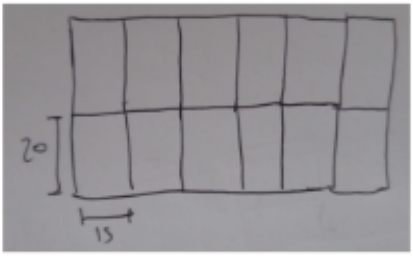
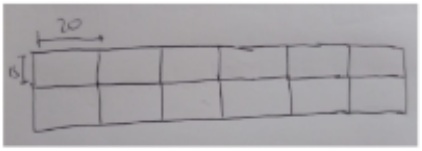
Ill.91. Possible placing spot in Ubat

This activity provided valuable data as to what the maximum size requirements for the product. In addition, the required size for the concept to be self-sufficient is needed. From Appendix 10, it can be found that 48-60 microgreen trays are needed and approximately 105 leafy green cups to be self-sufficient. These numbers are found by approximating how many kg of green each tray provides and comparing it to the restaurant needs. Please visit mentioned appendix for a full understanding.

The next step, is to combine the information for maximum size requirement and number of trays needed. This combination will give insight to the dimensioning of the concept.

The maximum dimensions for the product are of 90cm width and 50cm depth. There is no limitation for height, only the roof.

To simplify calculations, the microgreen tray size is used. The tray has dimensions of 15x20 cm and the smallest size combination in the restaurant from the pictures above is 50x90 cm (without height restrictions). The table below represents a possible combination of number of trays and layout. Please keep in mind that the number of trays should be between 48 and 60 so that the restaurant can be self-sufficient. Furthermore, two of the levels should be for germination.

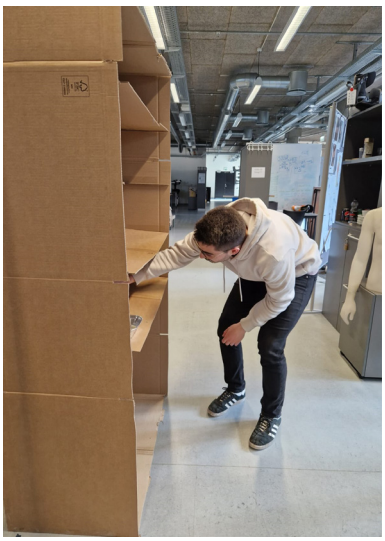
Amount of trays per level	Size needed per level if the trays are placed vertically	Size needed per level if the trays are placed horizontally
8 trays (requires 7 levels to be safe since between 48 and 60 trays are required)	Total tray size 60x40cm 	Total tray size 80x30cm 
10 trays (requires 6 levels)	Total tray size 75x40cm 	Total tray size 100x30cm 
12 trays (requires 5 levels)	Total tray size 90x40cm 	Total tray size 120x30cm 

Ill.92. Chart with diferent onvinations of trays to delimit the size

In red, the tray sizes that would not fit in the restaurant are marked. Because there are still 4 combinations possible, the team decides to make cardboard mock-ups to test the size and practicality of these. The reason for this is that having more layers, means that the concept is taller and the average person might not reach the top layer. Likewise, having too few layer might mean that to interact with the bottom layer persons stance might be uncomfortable.

Heigth and practicality

To do this test, the quick and dirty prototyping together with the try-it-yourself method are used. The aim is to find out what the tray size arrangement should be so that the size of the product can be approximated. For this test, a quick mock-up is made on a 1 to 1 scale. It is chosen to build the mock-up with a width of 75cm and add rails so that the hegiht of the layers can be changed.



Ill.93. Testing out the accesibility to lowest shelf

Ill.94. Testing out the accesibility to lowest shelf 2

Ill.95. Testing out the accesibility to lowest shelf when lifted 10cm

The height of the bottom layer is estimated to be at 70cm. Here space for three drawers and the water tank are left. As can be seen on the images to the left, in the Illustrations 93 and 94, the user looks uncomfortable and is bent over in a weird position to reach the trays at the back of the layer. To correct this positiong, the mock-up is raised 10cm. In Illustration 96, it can be seen how the positioning is more natural for the user.

Ill.96. Testing out the accesibility to highest shelf when 7cm has been added for 6 layers

Ill.97. Testing out the accesibility to highest shelf with 7 layers

The illustrations above show that for an average size person (177cm) having a total of six layers, two of which are for germination, is the necessary hight. Adding another layer it means that a stool is needed to comfortably reach the top layer.

With this infomation, it is possible to disregard having 7 layers with 8 trays. Furthermore, the group observed that with the 1 to 1 scale mock-up of 75cm width, the concept seemed already very big and if doors had to be incorporated, increasing the size seemed uncomfortable. Additionally, a concept that is smaller in width but taller in height was found to be better stuited for restaurants. For this reason having 5 layers with 12 trays was also disregarded.

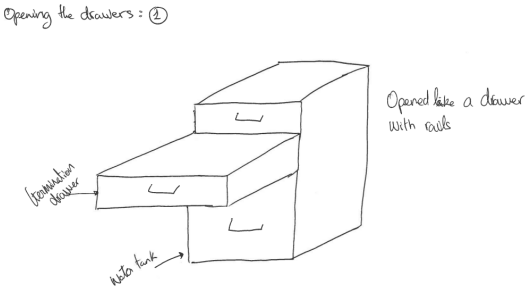
The group chooses 10 trays per level and show that it is also okay with the amount of leafy greens.

Interaction with the germination and storage area

One of the positive feedbacks obtained from the chef at Nordur where the prototype was left, was that there was space in the drawer to have storage and the germination trays. Because of this, the storage for germination and keeping os growing mediums and seeds is incorporated into the concept.

In Appendix 11, where the number of trays needed is calculated, it is seen that restaurants approximately use six trays a day. Since the germination process takes three days and there is space in each level for 10 trays, only two levels are needed for germination. An additional level is added to have extra storage for growing mediums and seeds.

In Appendix 11, it is possible to find the exploration dive into the interaction of the user with the storage area, where different door possibilities are explored and tested with real-life mechanisms. In the end, it is decided that the drawer would be the best option.



Ill.98. Sketch of drawer interface

Ill.99. Drawer interface in real life

Ill.100. Drawer interface in real life 2

The main reason for choosing this option is the accessibility to the trays that would be at the back of the drawer. If the accessibility is wanted with one of the other options, it would be necessary to add the same system as with the drawer and therefore making it the better option.

Developing the water tank area

To fill up the water tank, different possibilities are explored. These are:

-Connecting the concept to a water supply
-Using a water hose
-Using a water jug
-Taking the water tank out of the concept to fill it up under the sink

These different possibilities require different designs for the water tank. The full development of the water tank can be found in Appendix 12.

Ill.101. Water hose

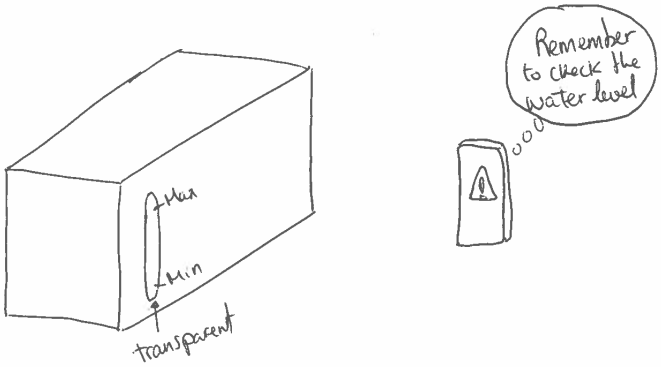
From mentioned Appendix, it is possible to conclude that having a water supply in the restaurant's dining area is very uncommon and therefore this option is disregarded. Since the water tank can weigh up to approximately 40kg when full, filling it up under the sink is also disregarded since it would mean the user has to carry it and place it back in the concept. With these decisions in mind, the remaining options simply require a water inlet on the water tank. The positioning and interaction with the inlet are explored in thre same Appendix and it concluded that the best solution is to have to inlet on the top of the tank and simply using the same mechanism as a bottle cap.

Ill.102. Water tank

Feedback for water level

If the water in the water tank falls under a certain level, the water pump will not be able to pump water since it will start sucking air. If this happens, the pump would break and therefore the greens would not get watered until the pump is replaced. To ensure this does not happen, different possible prevention systems are explored and can be found in Appendix 13.

During a milestone meeting, a question was raised as to whether too many features were being added to the design. Because of this, the group decides to take a step back and look at the essentials for the product to work. Here it is found that only the water pump, the lights, the fans, and the motherboard are necessary. Because of this, the decision of removing the water level sensor is taken. Instead, it is decided to have a transparent slit on the water tank through which the user can see the water level. Additionally, the smarthphone app should notify the user every two days to check the level of the water tank.



Ill.103. Water tank sketch , water level indicator

Activity reflection

During the development of these key interactions, some working princples have been found that should be incorporated.

-Drawer mechanism for the germination and storage space

-The water tank is to be filled up using a hose or a jug. In addition, the the lid use use the same mechanism as a bottle cap

-No sensor is to be used to provide feedback on the water level. Insetad the app should notify the user every two days

Moodboard

To get an idea of what the overall product should look like, what materials should be used, and what type of finishes would fit best in the restaurants, a style board is made.

Two clear different possibilities were found. One path was to base the design of the concept on wooden furniture from the restaurants and the second path was to base the design on steel/ aluminum appliances like the wine fridges that restaurants have on display in the dining area.

Ill.104. Moodboard

Wood concept for feedback

Under the assumption that designing the concept in wood would drastically reduce the CO2e emissions in comparison to the steel/ aluminium structure, a wooden design was quickly made in SolidWorks and rendered to get a professional opinion on the feasibility and actual design of the product. At this point, the concept looked like the image below (it is still missing glass doors to avoid customers in restaurants sneezing, coughing on the greens, or touching them).

Ill.105. Render of all wood structure

Feedback architect / industrial designer

As mentioned previously, an expert opinion is wanted on the feasibility to build it and the design of the product. For this reason, Torben Wahl, educated as an architect but an industrial designer by profession is contacted. During the conversation, the group expressed the idea of using oak as the material, the overall size, the need for doors on the product to avoid people coughing, touching, and sneezing on the greens, and the use of the product.

The expert's initial thought is that there is too much timber. Because of the amount of timber and the price of it at the current time of the project, he believes it to be excessive. Making a product of the required size with the required oak would make it too expensive for restaurants to be able to afford the product.

Furthermore, he raises awareness of the maintenance of the wood since there is water involved in the product. Meaning that the wood would have to be protected every x amount of time.

His suggestion is to consider simplifying it using an aluminium frame and some sort of glass/ plexiglass panels for the surroundings, making it look like something closer to the Illustration 106 below.

The last concern he points out is the positioning of the fans. He believes them to be in an awkward position if the waiters or chefs have to harvest the greens.

Ill.106. Silvan green house (Vitavia, Minidrivhus PÅ hjul, urban, sort - Køb Minidrivhuse online: Silvan)

Activity conclusion and reflection

Before contacting the industrial designer to get feedback on the design, the group had conducted research to see if oak would be able to resist water. However, during the interview with the designer it was a surprise to hear that the price of that timber was extreemly high and it had not been considered. The positioning of the fans had not been considered much before the interview since the group wanted professional opinion before continuing on the design.

The meeting with the industrial designer was very productive and gave great insights to the group as to how to proceed with the design of the product. The feedback is considered and the design changed. The following sections explore the new considerations for the design of the concept.

It is assumed that changing the materials would exponentially increase the CO2 emissions even though it means that it would be cheaper to manufacture.

In this case, the affordability of the restaurants for the product weighs more (to make a decision) than reducing the CO2e emissions of making the product. The reason for this is that if the restaurants do not even buy the product in the first place, the CO2e emissions of plastic packaging for vegetables would not be reduced. However, if increasing the CO2e emissions to manufacture the product means that restaurants would buy it, it is seen as positive even though the CO2e emissions breakeven would take longer to achieve than with the concept made out of wood.

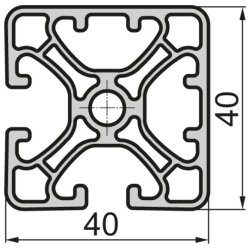
Change of material

Taking Torben's feedback into account, a new design is made. The main focus points of the new design are the metal frame, the side panels and doors, and the plastic components. In general, throughout the design of the product, the team has avoided the permanent joining of the components. The reason for this is that it is believed to be a better solution for maintenance since the single component can be replaced if broken. Furthermore, at the end of the product's life, the aim would be to disassemble the product and repurpose the components for a different product.

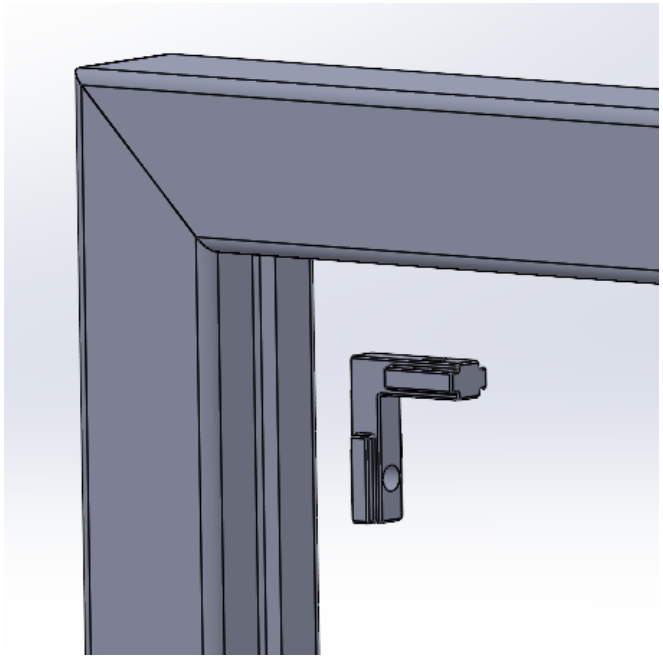
The development of these three parts is shown as linear but are, in reality, developed simultaneously because they are interrelated.

Frame design

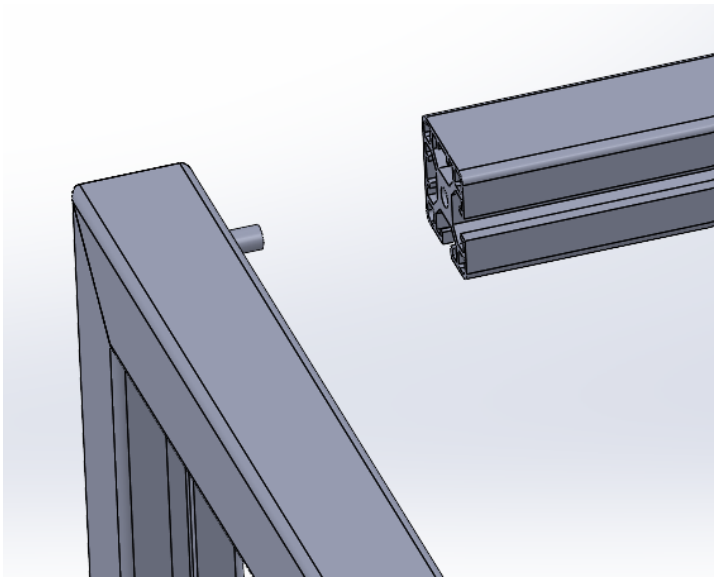
For the design of the frame, it is decided to use aluminium extrusions, please see Appendix 14 for all considerations and options. One of the main reasons for choosing this material is the possibility of using the extrusion's t-slots to join different components. One other reason is the fact that by using recycled aluminium, the CO2e emissions can be reduced by 6 times, and is, therefore, a requirement that the aluminium is recycled. The extrusions chosen are from a company called Rollco in Sweden:



Ill.107. Aluminium profile

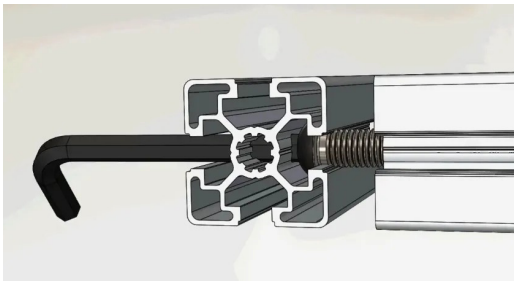


Ill.108. Hidden angle connectors



Ill.109. M8 bolt connection

The height and width are connected via hidden angle connectors**.** The reason for using these is that is has a clean and professional look in comparison to outside angle brackets. The depth extrusion, however, cannot be conected using these because the side panels have to be in there. For this reason, it is decided to use an M8 bolt. For this to be a possibility, the depth extrusion´s hole has to be threaded and the height and width need to be drilled so that a screwdriver can be used to tightened the bolt:



Ill.110. Joint M8 Bolt connection. (How to join Aluminium Profiles)

Door and side panel

Ill.111. Glass doors

The whole point of changing the design, apart from reducing costs, is to improve the design and visibility of the greens by having transparent panels on the sides too and not only on the front. CO2e emissions and the price for different materials are looked at to choose the most suitable option for the project. In Appendix 15, the evaluated options can be found. The final choice is to use glass as the side panel and door material because, for both CO2e emissions and price of the evaluated materials, this is the least expensive.

Glass	Total price: 773,25dkk	Total CO2e emissions: 21,27kg
Plexiglass	Total price: 844,47dkk	Total CO2e emissions: 48,93kg
Polycarbonate	Total price: 1006,62dkk	Total CO2e emissions: 48,93kg

Ill.112. Door knob

The door's visual expression and physical interaction for the user are further developed. The doors are left frameless to express to the user the delicate content behind them. At the same time, it reduces material which helps both the price and CO2e emissions.

The hinges supporting the door are also explored in Appendix 15. The final choice is the hinge with spring lock since it would prevent the doors from closing on the chef while trying to take out some greens.

Finally, the door handle is also explored in the same Appendix. Here, the aim is to find a handle that would again express the delicate feeling to the user. Because of this, the chosen option is a cylinder knob.

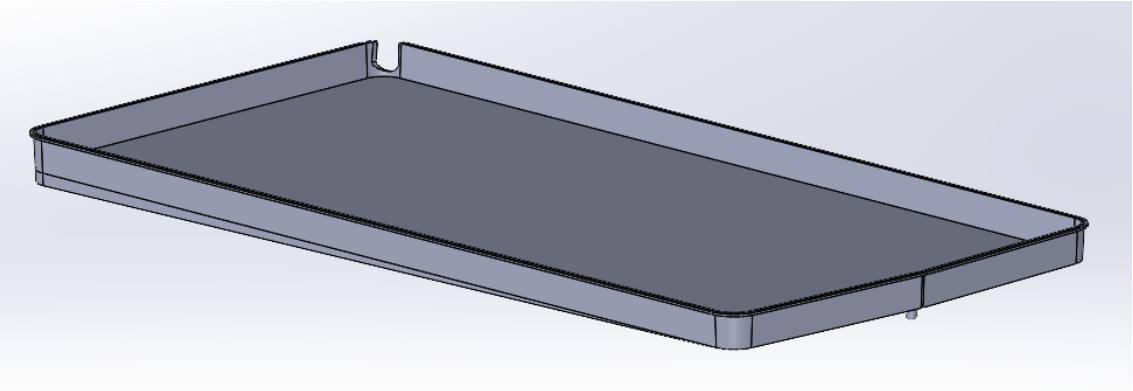
Reflection on the activity

This activity allowed the group to completely develop and unfold the door and side panels. Trying to both keep costs and CO2e emissions down. Furthermore, the interaction with the door and feeling when opening it were explored.

Tray design

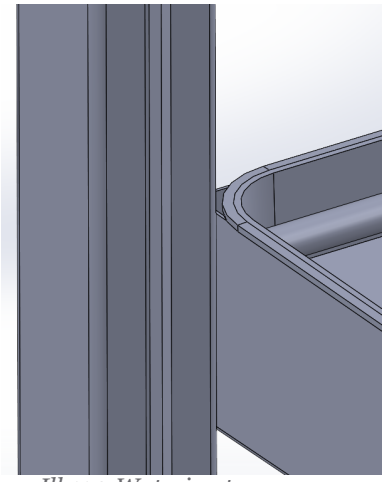
The design of the microgreen tray, leafy green tray, water draining tray, and support tray are all done simultaneously. This is done because some details of the trays are interdependent, the full development of the trays can be found in Appendix 16. The design of the trays is based on the interdependency between them and the interaction with the user since they would have to take them out to harvest the greens and restart the growing process.

Waterig tray



Ill.113. Watering tray

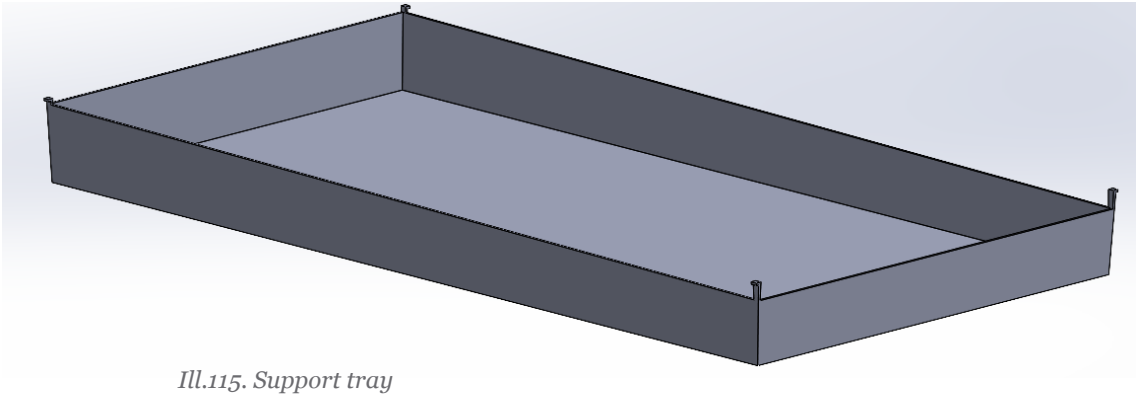
In the watering tray, the surface is not flat but inclined in a 1:40 ratio so that the NFS (nutrient film solution) can travel down to the outlet pipe and back into the water tank. A small support rim is added around the tray so that it can lay on top of the supporting tray without falling in:



Ill.114. Watering tray corner

Support tray

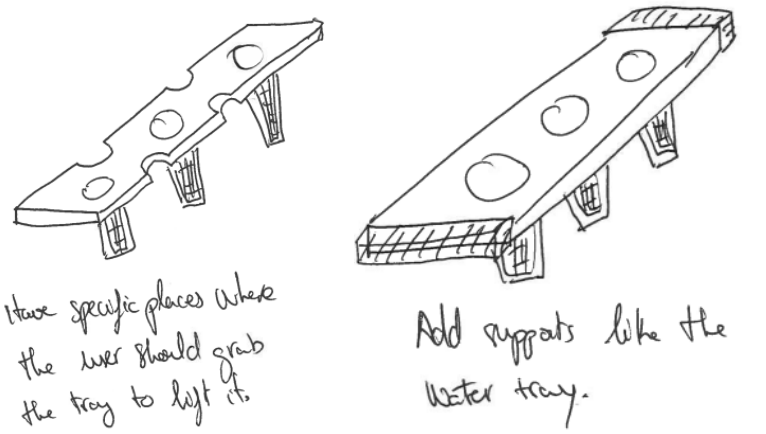
During the design of the support tray, small hooks were added to the design so that it could easily be slid into the frame and attached without having to use screws.
A concern is if the hooks can support the necessary weight. This will be tested with a simulation in a later chapter.



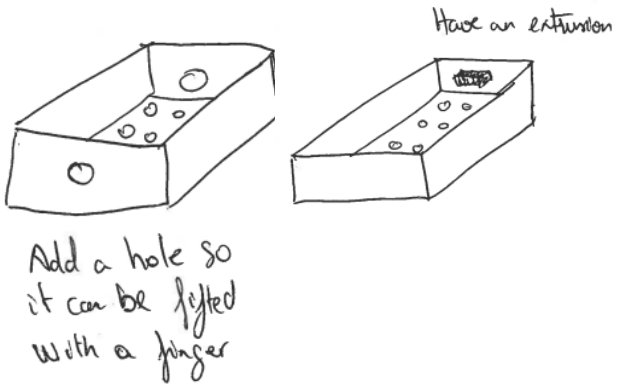
Ill.115. Support tray

Greens tray

Finally, the microgreen and the leafy green trays. These two need to, every day, be picked up and put down by the user. Because of this it is important that they are easy to interact with. In Appendix 16 different proposals are explored, from having a hole for the finger so that the user could pick it up, to having an extrusion from which the user could pick it up.

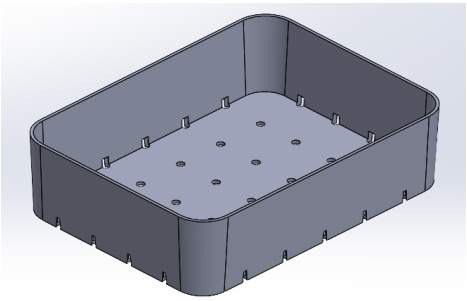


Ill.116.Sketches developing leafy green trays

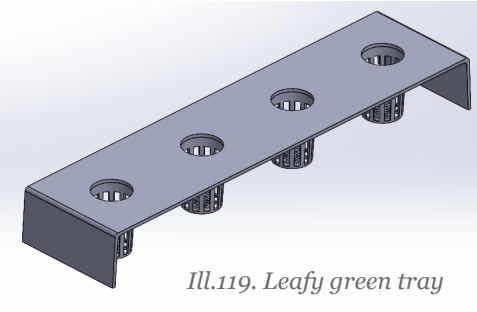


Ill.117.Sketches developing microgreen trays

Eventually, it is decided that the best option is to reduce the height of the watering tray so that these two trays would stick out in height. This decision is made because it reduced a lot of material being used for the draining tray and allows the user to comfortably pick up the two green trays.

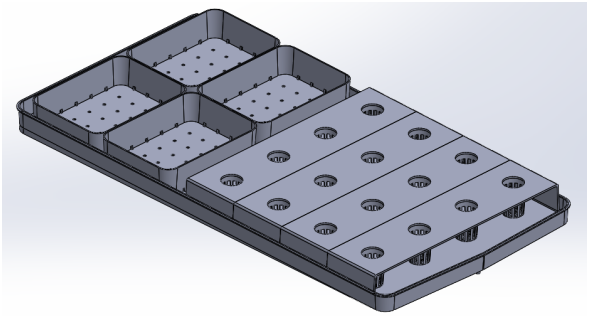


Ill.118. Microgreen tray



Ill.119. Leafy green tray

The reason for the leafy green tray to have two extrusions facing down is to avoid them from moving in the “depth” direction of the product.



Ill.120. Leafy green tray + microgreen tray + Watering tray

Through desktop research that can be found in Appendix 17, it is decided that the best material for these custom parts would be Terralene. This is a 100% bioplastic that is also 100% recyclable. This plastic meets the necessary requirements for the trays since it is food safe and dishwashable. To ensure that it is strong enough, a simulation is to be performed in a later chapter.

Combination of the components

While trying to put all the components together it was realized that the drawers could not be placed as there was no place to attach them to, Therefore the group decided to add part of the side panel in wood, this wood could be also specificlty chosen by the restaurant, so it fits better with the decoration already placed.

Ill.121. First try to combine components

Ill.122. Combination of components after changes

FURTHER WORK

At this point, while doing quick renders, the group realised of the possibility to customise the wooden panels for the different restaurants. This is something that should be further developed.

A different render presenting the possibility to change colour.

Ill.123. Render of product With trays darker wood

7

DELIVER 1.0

This is the final chapter. The aim of this chapter is to close the solutions space and provide answers to questions that are still remaining open. Here different aspects like the simulations, business models, electronics, and the app are further discussed.

Production methods

For the production methods, it is necessary to know how many units of the product will be produced. The reason for this is that small-scale production and large-scale production require different production methods. The group estimated that in the first year, it would be possible to have 20 customers, increasing by 10 customers each year during the first five years (20-30-40-50-60 customers), the group would have a total of 200 customers. Each customer would need two units (one leafy green and one microgreen) which means that, in the first year, 40 units would be sold (20 microgreen and 20 leafy green units). After five years, a total of 400 units would be sold (200 microgreen and 200 leafy green units). Because of this, the small-scale production is utilised for the first 40 units, and then the big-scale production would take over. Because overall, the amount of units is so small, the group believes that it does not make sense to buy machines for small-scale production or for big-scale production. Because of this, all the manufacturing is outsourced

The product is composed of 3 kinds of components.

-Standard components:

These components do not require any added manufacturing processes.

-Semi-custom components:

These components are, the aluminium extrusions for the frame, the glass doors, and the different wood panels used for the outside casing and the drawers.

The semi-custom parts only require some cutting to size and some holes. The group will outsource the small-scale production to a workshop where they will use laser cutters, electric saws, and vertical drills. For the big-scale production, the group will outsource the components to a different, bigger workshop that also utilises CNC machines and water jet cutters. The reason for these two differences is that it is believed that for the first year with such a small production amount, the smaller workshop would be cheaper and, as the production expands, the bigger workshop would be cheaper in the long run.

Ill.124. CNC machine

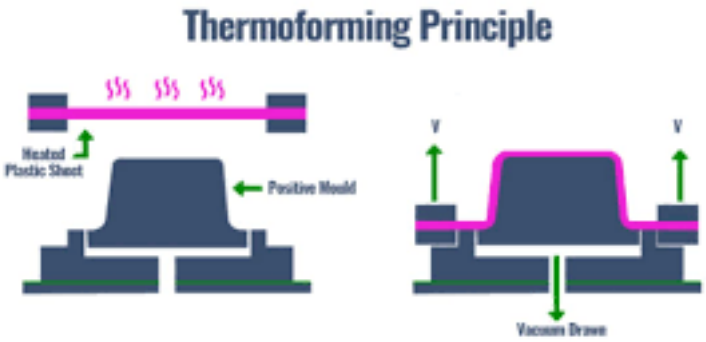
Ill.125. Water-jet cutter

-Custom components (that have to be manufactured from plastic sheets and therefore required a mould)

These components are the bioplastic parts. Mainly the four trays that were developed in the previous chapter and the water tank with its lid and the inlet lid.

For these components, both injection moulding and thermoforming were considered. The group contacted a company in Spain that manufactures recycled and bioplastic components. A price estimation was received for some of the necessary moulds. These moulds were for injection moulding and can be found in Appendix 17. The price for these moulds, because of the small number of parts needed, would not be worth it even in the long run (for example one moulds price is 69000 euros which after 5 years would be used to manufacture only 1600 parts. The price per part is of 43 euros). From desktop research, it can be found that injection moulding should, ideally, be used for high volume production. It also has higher precision and higher tooling costs. Thermoforming, on the other hand, can be used for small-scale production and is much cheaper respectively [xx]. With all of these considerations, it is decided that thermoforming is the chosen manufacturing process.

Ill.126. Injection molding machine



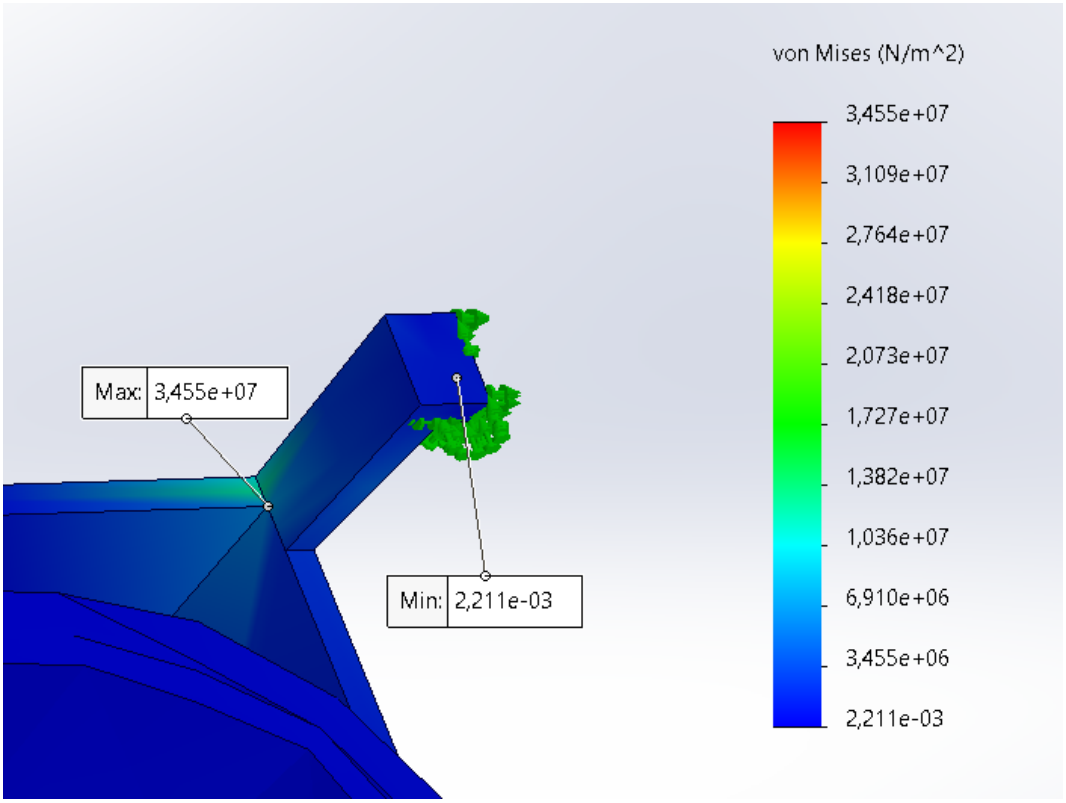
Ill.127. Thermoformin principle

SIMULATIONS

During the development of the product, three specific areas were found where the group was unsure if the design would be able to withstand the physical necessities (in other words, be able to support the necessary weight).

-The plastic trays supporting the leafy greens ' weight (this would be the worst-case scenario)

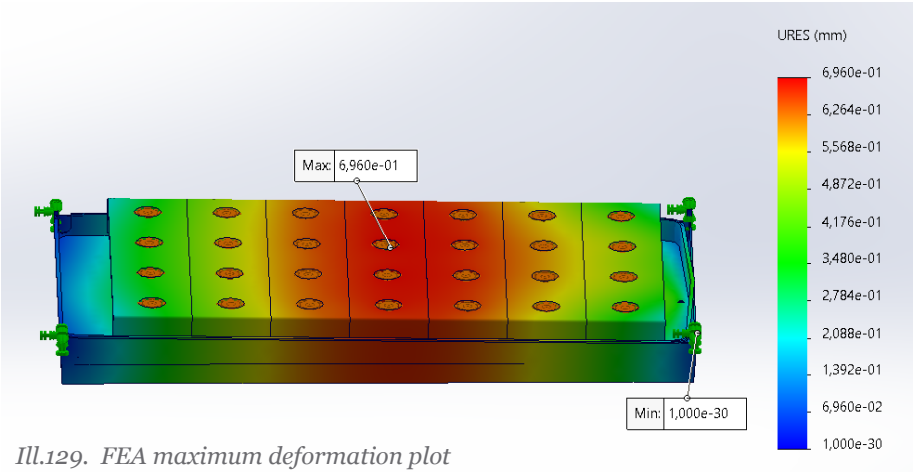
The worst-case scenario is that the support tray and draining tray have to support the weight of the leafy greens. It is assumed that, on average, the leafy greens can weigh up to 0,5kg and since there are 28 growing pots per level, the trays would have to support 14kg. The simulations are done with 20kg to ensure they would be able to hold.



Ill.128. FEA stess plot support tray

The maximum stress found is 3.45x10^7 (obtained from SolidWorks). Because it is well below the elastic modulus of the plastic, which is 8.96x10^8 (obtained from SolidWorks), it is assumed that under the load, the plastic would not deform permanently.

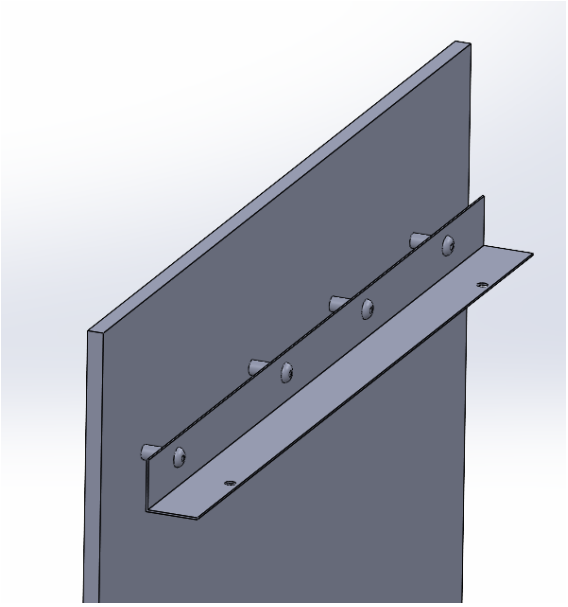
When looking at the deformation plot of the trays, it can be seen that the maximum deformation is of 0.7mm. With this deformation, the group does not believe that it will be a problem.



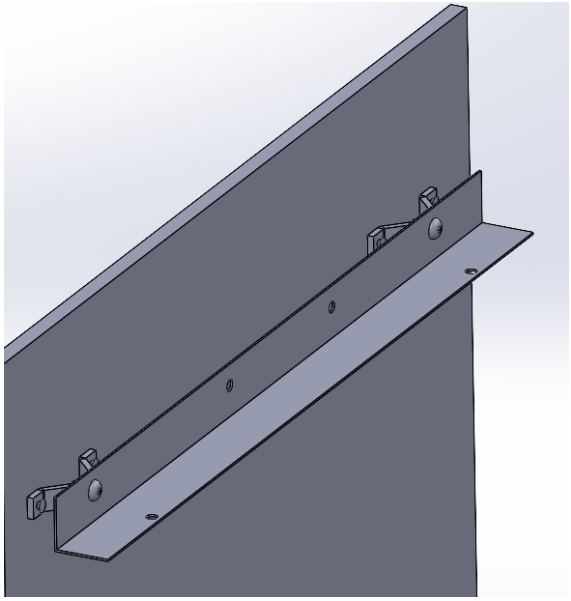
Ill.129. FEA maximum deformation plot

-The wooden side panels and the screws are able to support the weight inside the drawers

The wooden side panels where the rails are screwed into, are only 8mm thick. Because of this, it is assumed that the maximum depth of the screws should be 5mm. In the initial design, the following setup was used:



Ill.130. Initial set up of rails

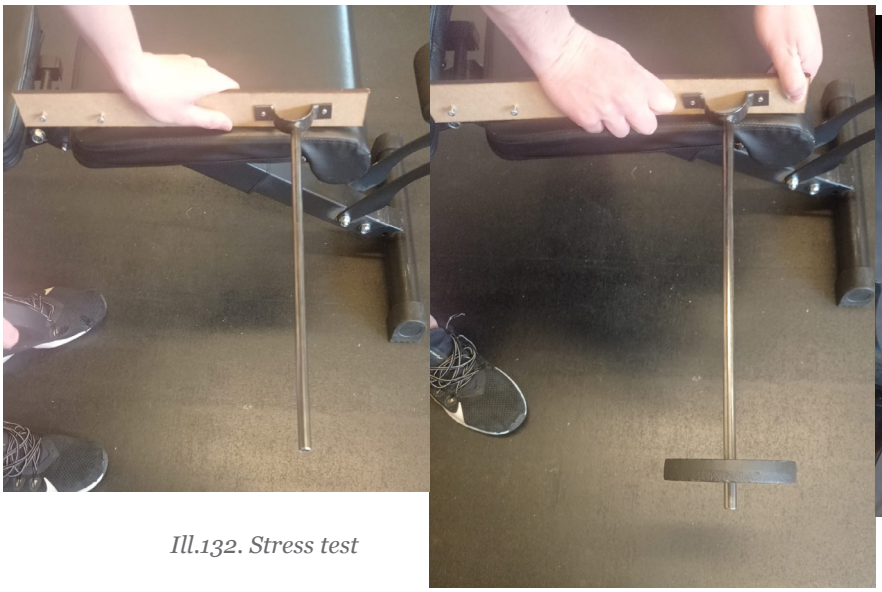


Ill.131. Second set-up with new spacer

In the second set-up, the force applied to the screws is much closer to the wooden panel. To ensure this design would withstand, a physical mockup was built to test the strength (only a quarter of the design was tested). The drawers would have to support a total of approximately 3kg from the stainless steel weights that accelerate the germination process. Because of this, the test is performed with 1.25kg.

When adding 1.25 kg, the wood, and screws are able to hold. The next step tested is with 2.5kg just to see where the limit is. In this case, the test failed and the screws are pulled out of the wood.

It is believed that the design is good enough for now, but for a future product, it may be better to add some more contact points or to have the screws placed in a vertical manner instead of horizontal.

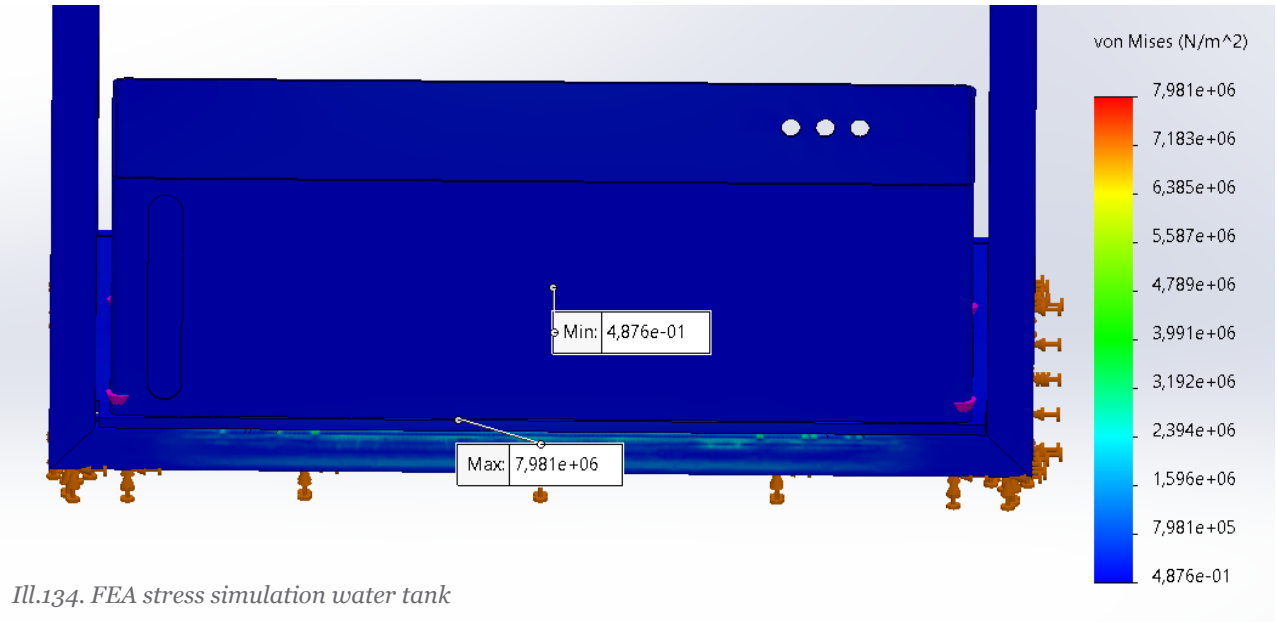


Ill.132. Stress test

Ill.133. Wood breaking

-The bottom wooden panel being able to support the weight of a full water tank

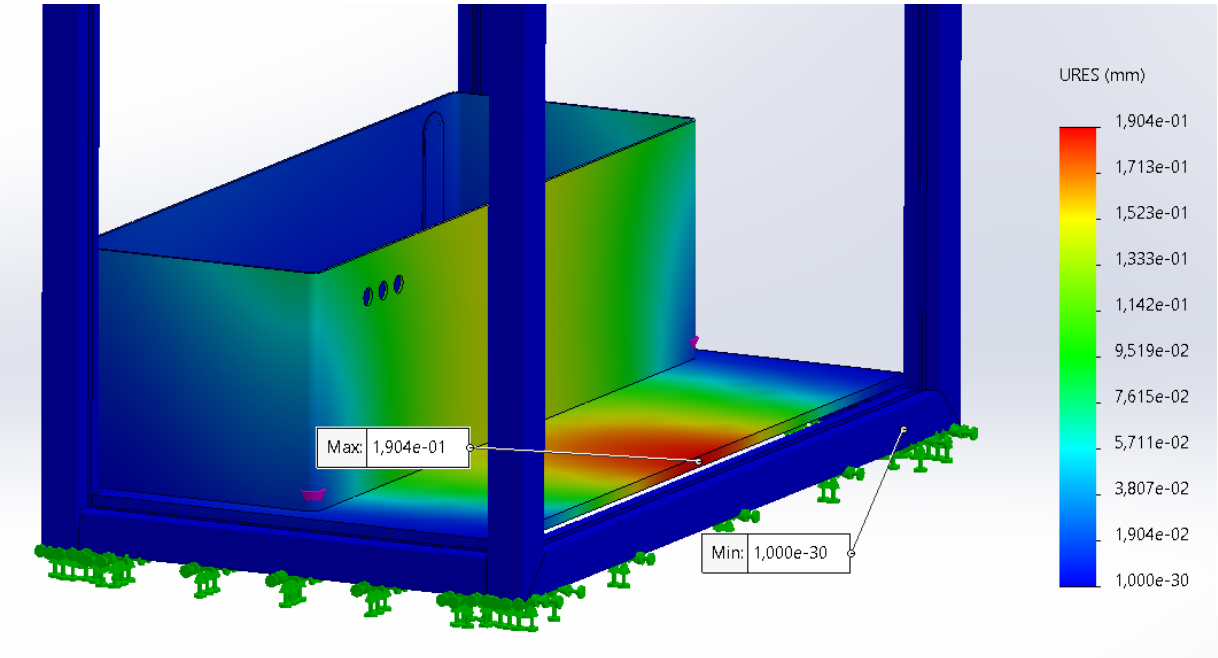
When full, the water tank is the heaviest component of the product and weighs 40 kg. To ensure that the wooden panel on which it is laying can support it, a simulation is made. For the simulation, a safety factor of 1.5 is used. The simulations shows that the maximum stress is transferred from the wood to the aluminium:



Ill.134. FEA stress simulation water tank

The maximum stress found is 7.9x10^6 (from SolidWorks). Because it is well below the elastic modulus of the aluminium, which is 6.9x10^10 (found from SolidWorks), it is assumed that under the load, the aluminium would not deform permanently.

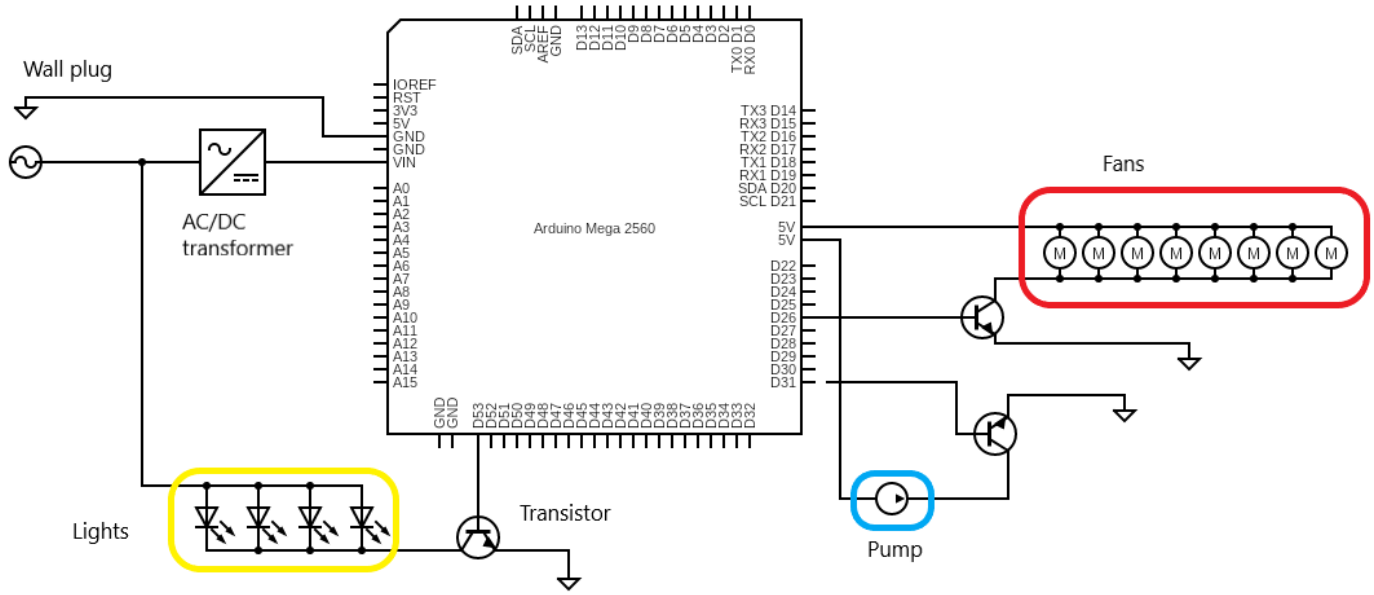
When looking at the deformation simulation, it can be seen that in the worst-case scenario, the wood only deforms 0.2 mm which is deemed good enough by the group.



Ill.135. FEA maximum deformation simulation water tank

Electronics system

Throughout the whole project, there was a constant debate amongst the team as to what type of sensors and electronics should be incorporated into the concept to provide feedback to the users. As mentioned previously, in a milestone meeting, feedback from the supervisors was that it looked like there was a feature creep in the concept where more and more things were being added without considering the CO2e and cost implications that it implies. Because of this, only the basic electronics are used for the concept. Any other types of feedback, like keeping track of how many days the greens have been growing or when to fill up the water tank, will be done via the app on the smartphone.

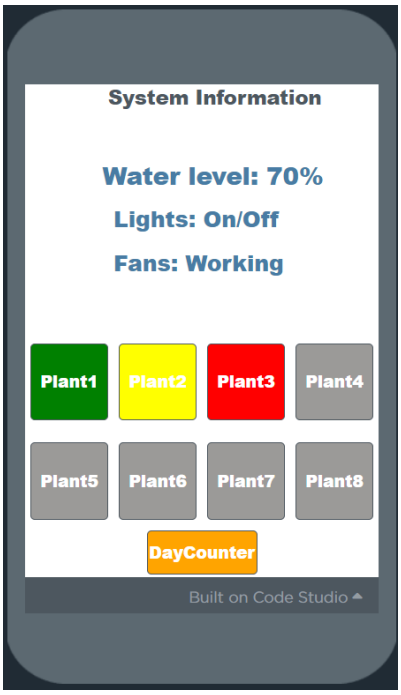


Ill.136. Arduino control

The Arduino mega, which is shown on the diagram in illustration 136, should be an Arduino uno with wifi instead. The reason for this is that it can then communicate with the app and give feedback to the user. Adding a wire from after each transistor to an analog input on the Arduino would allow the Arduino to know if the lights fans and pump are actually on or if there is some sort of problem. This would then be used to notify the user via the app that there is a problem with the product. The transistors are also placed after the lights, fans, or pumps to avoid the possibility of voltage or current going into the Arduino and frying it.

App development

The app for the project is also developed a bit. Code.org is used for this. The real app should use a timer synchronised with the timer of the Arduino which is not developed in the test app. Here, a day counter button is used that, when pressed simulates a whole day passing by. The idea is that the in the grey zones, the user can click and add the name of a new plant being grown and the date. The green areas indicate ready to harvest, yellow indicates almost ready to harvest, and red means newly planted. At any given moment, the user can click on them to see the status.



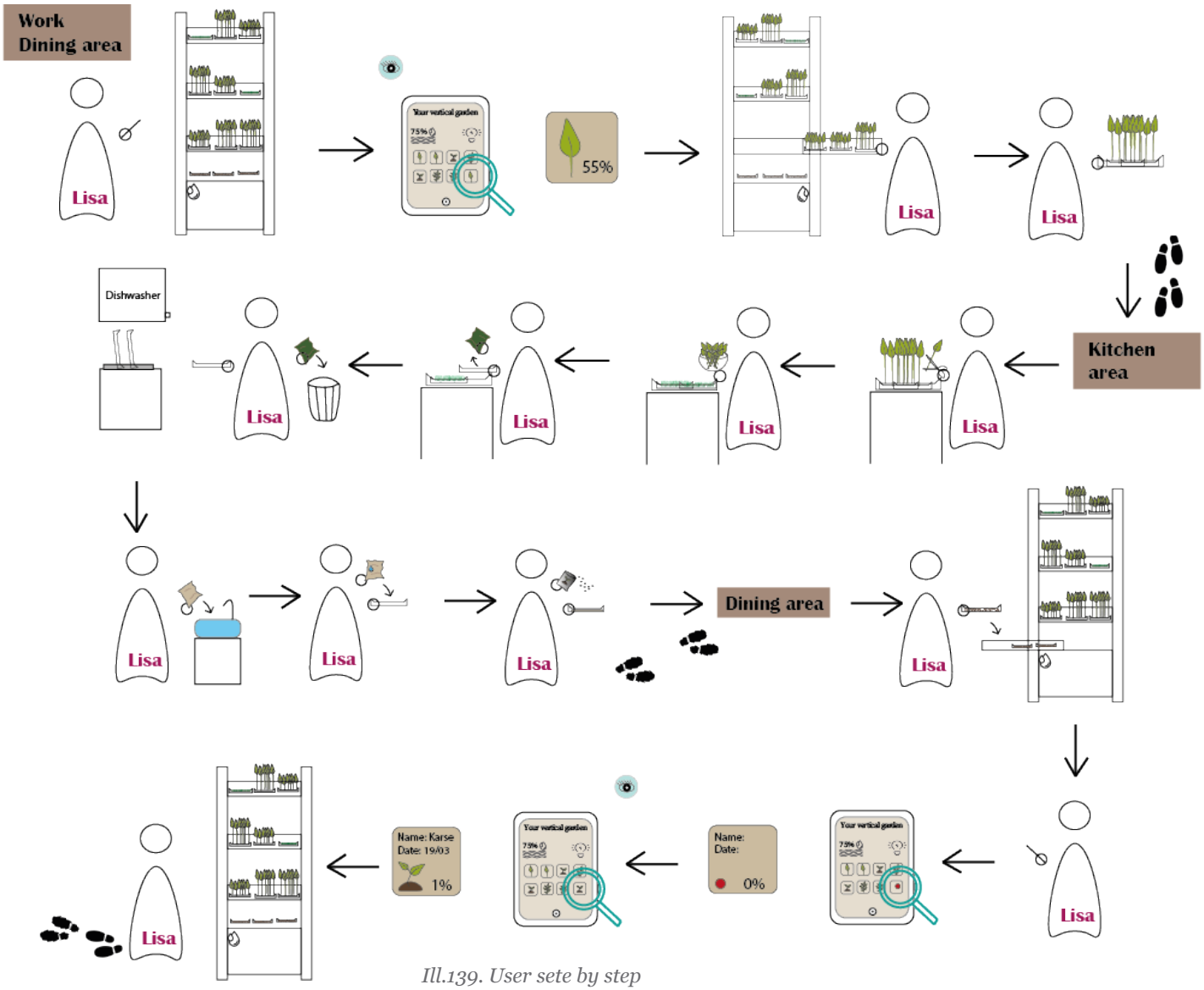
Ill.137. App interface trial

The QR code below can be used to test out the app (it expires on the 15th of June 2023). Only the first 3 boxes work. The aim is to click on 1, input the data and then click on Done. Because it is a test, it is necessary to only do one thing at a time and then return to the main screen. If box one is clicked and then box two is clicked without hitting done, a small glitch will appear.

Ill.138. QR code

User scenario

The full user scenario for the concept is developed. Here it is possible to see where it is similar to the current scenario and where it differs and adds work to the chefs.

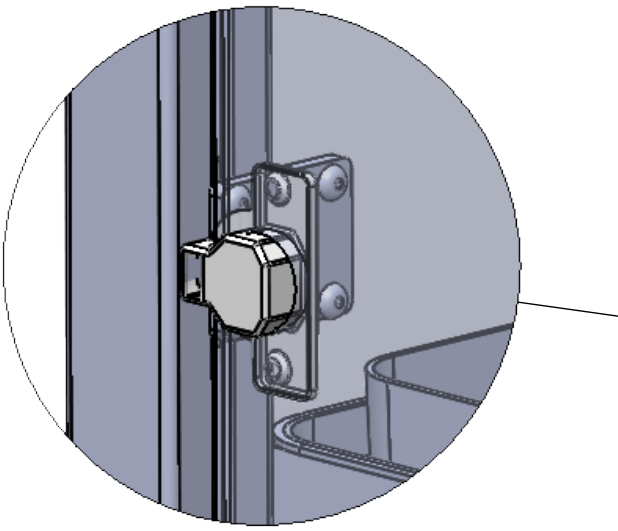


Ill.139. User sete by step

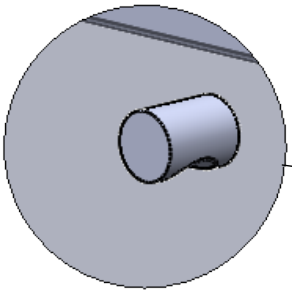
In the morning, the user checks the app to see what is ready to be harvested. Then they harvest and place the growing medium in the bin. The tray then goes into the dishwasher and the user has to prepare a new tray with seeds. This tray then does into the germination drawer and after three days it is put on the watering system.

Porduct specifications

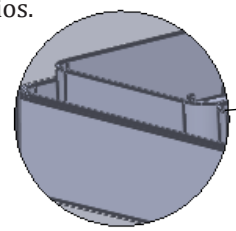
Spring hinges are used to avoid the door from swinging back and forth. Provides the sensation of a strudier design since the door does not have frames.



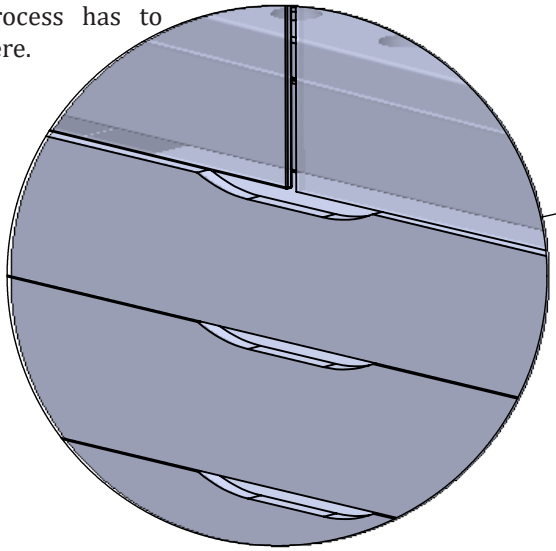
Small door know to indicate to the user that the door is delicate and the content it hides too.



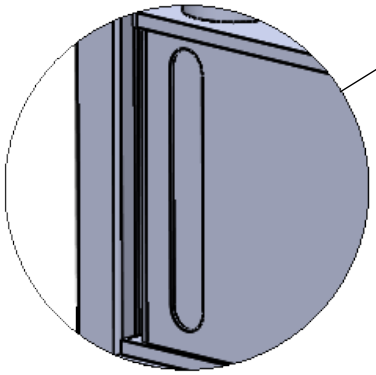
The trays have been lifted to ease the interaction of the user during the seeding and harvesting scenarios.



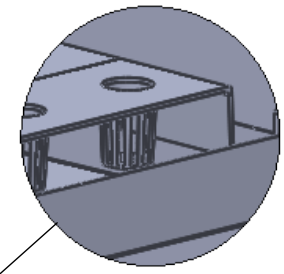
Germination and storage drawers have been added so that the whole product can be kept together. Otherwise the germination process has to happen elsewhere.

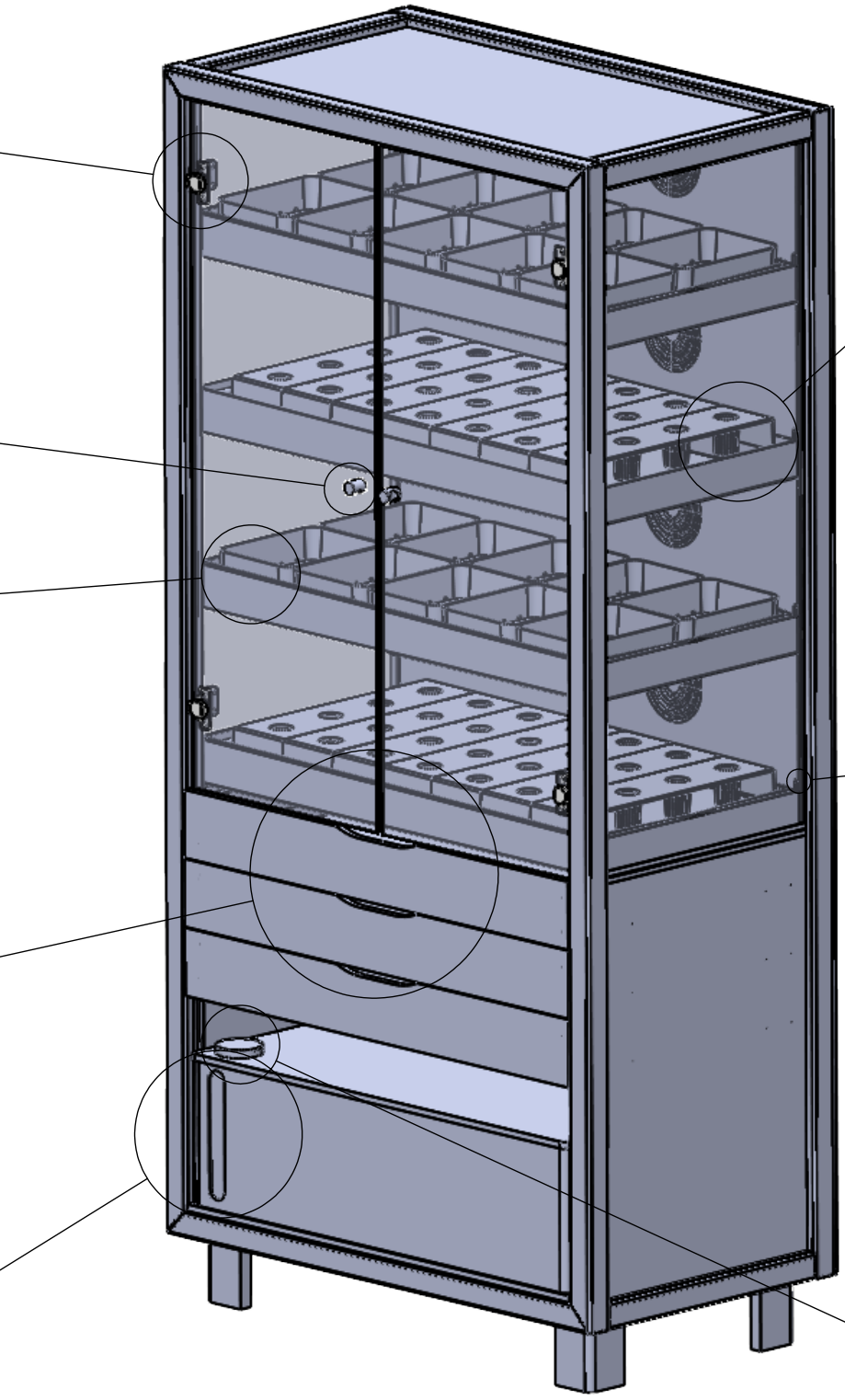


The tank has a see through slit so that the user can see how much water there is left in the tank.

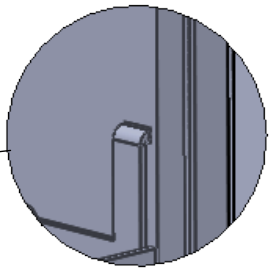


The leafy green trays have bent corners so that the user can easily lift them up and so that it holds the trays in place.

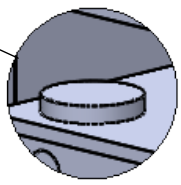




Hook-like connections are used to hold the support trays in place. The reason for these is that they can easily be put on and taken of of the product.



The water inlet is placed on the top of the tank so it is easier to access for the user.



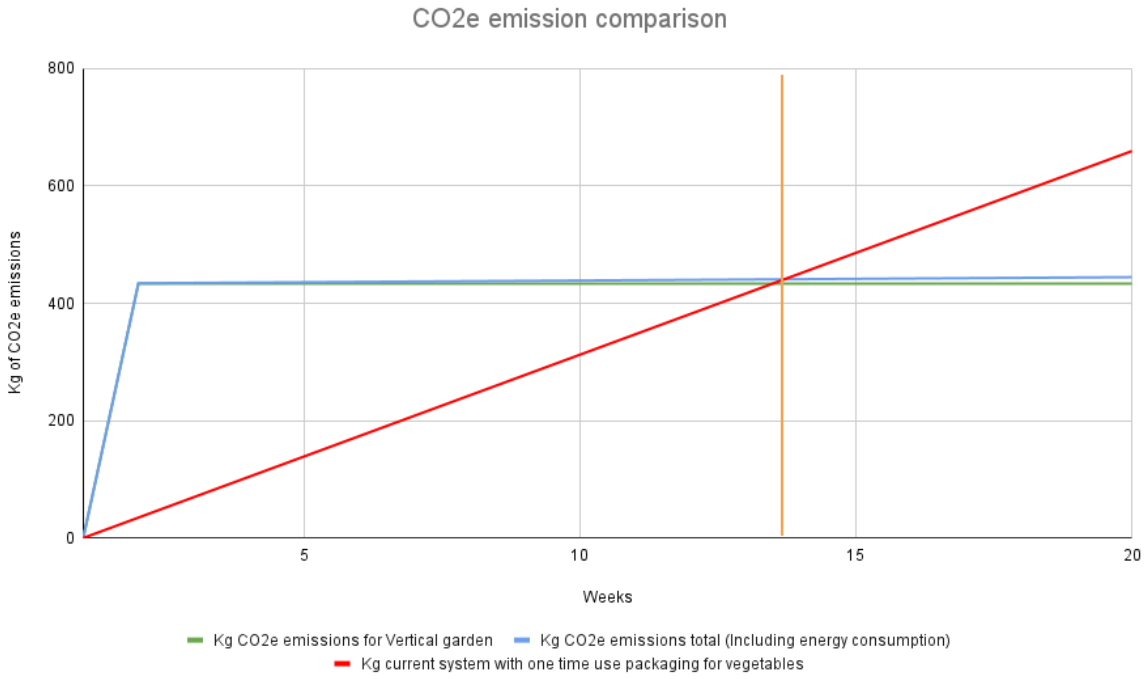
Ill.140. Specifications illustration

CO2e calculations

To ensure that the product is, in the long run, less CO2e emissions emittent than the current solution, some calculations are performed. To calculate the emissions, some assumptions and limitations have been made. In Appendix 18 the full report can be found.

The main limitations are that, like for the calculations in Appendix 18, the CO2e emissions consist of the emissions for the amount of each material and the emissions for the transport. The actual manufacturing processes through which each material is put through are not considered. Furthermore, the countries are treated as dots so if components are ordered from Copenhagen to Aalborg, this distance is not calculated.

Having done the calculations, it is found that for a unit of microgreens, the CO2e emissions are 228.53 kg of CO2e emissions. The CO2e emissions for a unit of leafy greens are slightly lower, 205.05 kg. Then, the CO2e emissions for the electricity needed to run the vertical garden were found to be 41.17 g a day. Using all of the information mentioned plus the calculations for the current system that can be found in Appendix 18, the following graph comparison is made.



Ill.141. CO2e comparison between the current system and to concept proposal

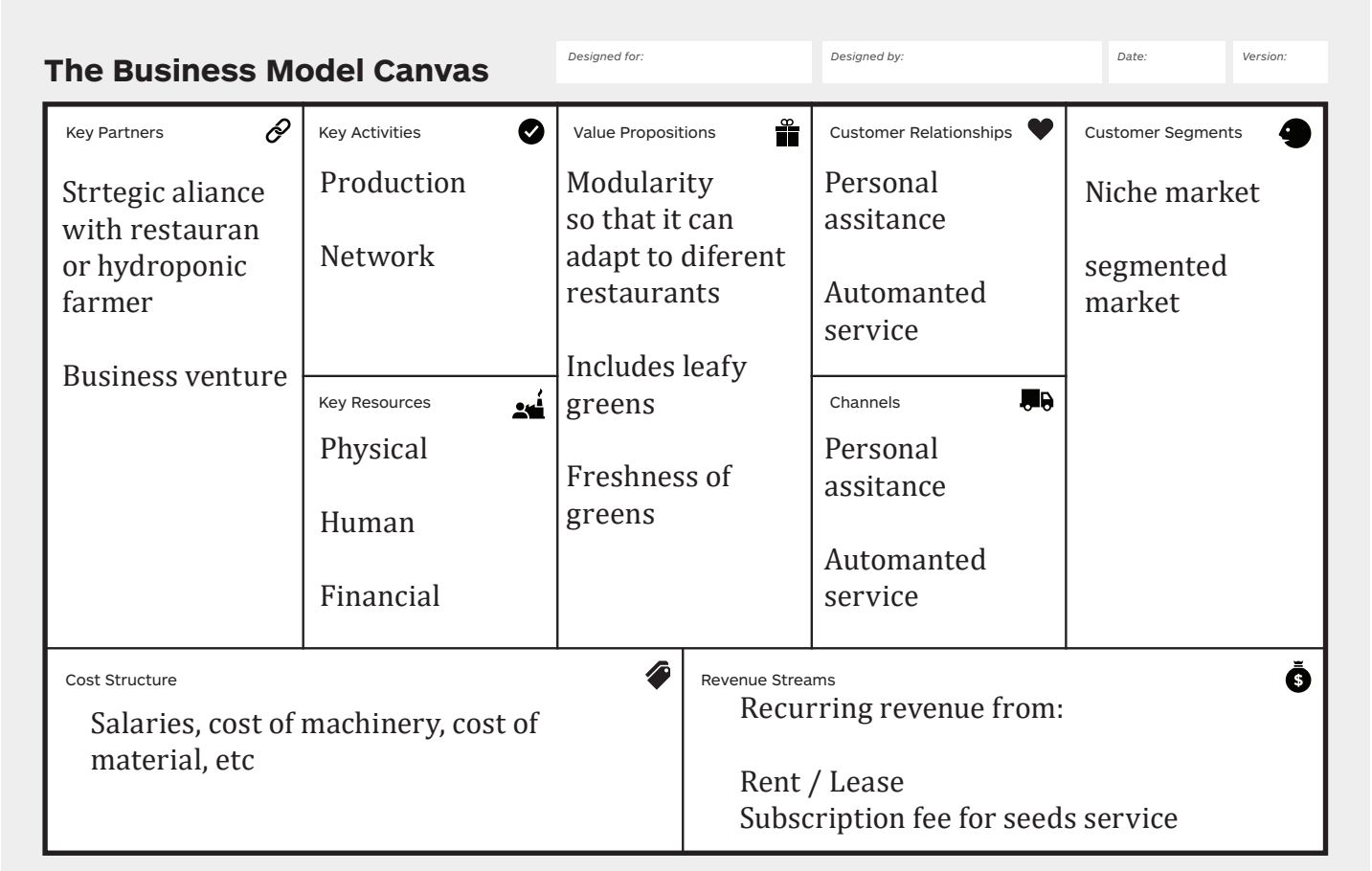
As can be seen in the graph above, the vertical garden's CO2e emissions would break even in comparison to the current system in just under 13 weeks with a value of 440.9 kg of CO2e. Because it is believed that the restaurants would keep the vertical gardens for a minimum of 2 years, this solution would drastically reduce the carbon footprint of restaurants consuming leafy greens and microgreens.

It is important to point out that these calculations are estimates where a lot of assumptions and limitations have been used because of the lack of information and time to make a full LCA study.

Business case

Business model canvas

To understand how the business is going to develop and expand in order to obtain profits, the business model canvas (BMC) is used. In Appendix 19, the full details of the business model canvas can be seen. The BMC is used to show in a visual manner how the different aspects of the business are developed. On the left-hand side of it, the aspects related to the business can be found and on the right-hand side, the aspects related to the customer can be found. In the middle, the value propositions from the product can be found [Osterwalder & Pigneur, (2013)]



Ill.142. Business model canvas

Some of the most important aspects to highlight are:

-The vertical garden allows them to be self-sufficient in both microgreens and leafy greens eliminating their dependency on their current suppliers to be able to deliver high-quality and necessary greens (because of weather and other factors, suppliers do not always have what the restaurants want).

-The product will be leased out to the restaurants for a minimum of 1 and a half years allowing them to return the product if they wish to. The reason for leasing it out instead of selling it is that restaurants would not pay a huge initial investment that they are not sure would pay itself out (this insight is found on page 49). The payment includes any maintenance services for the app or, if needed, the replacement of broken components.

-Finally, because of such low production units, no machines will be bought. All the manufacturing will be outsourced to lower the investment and it would only be the moulds that would need to be paid for.

Prices and cost

To calculate the production costs of the product, some calculations are made and can be found in Appendix 20. Here, the calculations are for each unit, one of leafy greens and one of microgreens. In this case, the calculations are made for a small-scale scenario, where there would only be 20 customers and each would have two units. The number of customers for the small-scale scenario and for the big-sclae scenario is an estimated guess that has taken many factors into account (restaurants that are believed to be genuinely interested, restaurants with the necessary amount of space, and current farmers insisting it is a very difficult market to compete in).

For the small-scale scenario, the total cost per unit would be 13767.22 dkk for the microgreen unit and 13544.11 dkk for the leafy greens unit.

Total price for standard parts	3512,00
Total price for material microgreens	5511,15
Total price for material leafy greens	5440,46
Total price for moulds per part microgreens	3707,06
Total price for mould per part leafy greens	3664,91
Total price for operations costs microgreens	583,15
Total price for operations costs leafy greens	494,93
Total price for overhead microgreens	145,79
Total price for overhead leafy greens	123,73
Total price assembly per unit	308,07
Total price per unit big scale scenario for micogreens	**13767,22**
Total price per unit big scale scenario for leafy greens	**13544,11**

Ill.143. Small-scale production prices

For the big-scale scenario, 200 customers are estimated and each customer would have 2 units. This amounts to a total of 400 units. In this case, the microgreen unit would cost8585.44 dkk and 8400.27 dkk for the leafy green unit.

Total price for standard parts	2618,08
Total price for material microgreens	4788,00
Total price for material leafy greens	4717,32
Total price for moulds per part microgreens	370,71
Total price for mould per part leafy greens	366,49
Total price for operations costs microgreens	400,46
Total price for operations costs leafy greens	312,24
Total price for overhead microgreens	100,12
Total price for overhead leafy greens	78,06
Total price assembly per unit	308,07
Total price per unit big scale scenario for micogreens	**8585,44**
Total price per unit big scale scenario for leafy greens	**8400,27**

Ill.144. Big-scale production prices

The biggest difference in price comes from the moulds. In the small-scale scenario, the mould price is divided by a smaller quantity of components than in the big-scale scenario. Some of it also comes from the operations costs but in relation to the mould costs it is negligible.

Market price of the product

As mentioned in the BMC the product will be leased out to the restaurants. Throughout the report, it was found that currently, restaurants spend approximately 1100 dkk a week on microgreens and leafy greens. Setting the price to 2000 dkk a month would incentivise restaurants to lease it since they would be able to save up to 2400dkk a month on leafy greens and microgreens. Setting the price any higher would discourage restaurants since then they would not see that much of a benefit because of the added work that comes with owning a vertical garden. As mentioned at the beginning of the report, chefs highly value convenience so the low leasing price would persuade them.

To see what the business case for the company would look like and if it is really worth investing in the concept, the Net Present Value for both scenarios is calculated. In both cases, some of the numbers that are used are assumptions as it depends on the real-world market, and no real infomation has been obtained.

For the best case scenario, 400 units would be manufactured. The customers would keep the units for 3 years and give them back to the company. The company would then maintain them if necessary, and hand them out again to another restaurant (this part is not included in the calculations).

	Time	Units sold	Development	Investment	Salaries	Production cost	Sales	Balance each year	Balance in bank account.
Year	0	40	-75000	-298549	-201412,75	-339714,2	480000	-434675,95	-434675,95
Year	1	60	-10000	0	-201412,75	-509571,3	1200000	479015,95	44340
Year	2	80	-10000	0	-402825,5	-679428,4	2160000	1067746,1	1112086,1
Year	3	100	-10000	0	-604238,25	-849285,5	3360000	1896476,25	3008562,35
Year	4	120	-10000	0	-805651	-1019142,6	4320000	2485206,4	5493768,75
Year	5	0	-10000	0	0	0	3600000	3590000	9083768,75
Year	6	0	-10000	0	0	0	2640000	2630000	11713768,75
Year	7	0	-10000	0	0	0	1440000	1430000	13143768,75

Ill.145. NVP estimation for the good case scenario

As can be seen above, the NPV after seven years is 13 million dkk. After seven years this does not seem like a lot of profit for the company. However, the company would only be with a negative balance for the first year, after that, the company would start making money.

For the worst-case scenario, only 40 units are manufactured. The customer keeps the units for 3 years and then hands them back to the company (here, potentially, the company could maintain them if necessary and hand them to a new restaurant)

	Time	Units sold	Development	Investment	Salaries	Production cost	Sales	Balance each year	Balance in bank account.
Year	0	10	-75000	-298549	-161130,2	-136556,65	120000	-551235,85	-551235,85
Year	1	10	-10000	0	-268550,3333	-136556,65	240000	-175106,9833	-726342,8333
Year	2	20	-10000	0	-402825,5	-273113,3	480000	-205938,8	-932281,6333
Year	3	0	-10000	0	0	0	480000	470000	-462281,6333
Year	4	0	-10000	0	0	0	360000	350000	-112281,6333
Year	5	0	-10000	0	0	0	240000	230000	117718,3667
NPV=	117718,3667		-125000	-298549	-832506,0333	-546226,6	1920000		

Ill.146. NVP estimation for the bad case scenario

As can be seen from the calculations, for the worst-case scenario, the Net Profit Value is of only 117718,26 dkk which after 5 years is not much. The company would not start generating profit until the 5th year.

From these calculations, in general, it can be said that the business is not very profitable. The reason for this is the low amount of units being leased out. To increase sales and profit, the market would have to be expanded to include other countries in Europe. It can also be said that when a restaurant returns the units back to the company, the company can easily maintain them and lease them out again. This second time the profit will be much greater since the first time the costs would have been paid off.

Update on requirerments to see what we meet/ dont

#			
1		Unknown	To know if this is true, a final prototype would be needed. It is believed however that he concept is well suited
2	Produce 6 kg of micogreens a week	Yes	It has 10 trays per layer and has 6 layers. This alows enough space for 6kg a week
3	Produce 4 kg of leafy greens a week	Yes	Selfsuficiency production of greens
4	It should be automatic	Partly	The watering system is automatic but the feedback system does not have any sensfors
5	Proper ventilation to avoid pests and mould	Yes	Has 8 fans to provide ariation
6	It should be multiple user friendly	Yes	Meetis the requirement by having the app
7	Easy to maintain and clean	Yes	Since none of the parts are permanently stuck together it is easy to maintain and clean
8	Should attain to the law	Yes	Even though not shown throughout the report, the authorities were contacted for information
9	12 to 16 hours daily	Yes	The timer on the motherboard controlles this
10	Full light spectrum	Yes	The bought LED lights are full-spectrum
11	Should only require up to 2 hours a week	Yes	It takes less than 20 min a day
12	The air temperature should be between 21-24℃ and the air humidity between 40-60%.	Unknown	No sensors are used to measure this but the air ventilation should help
13	Water balnaced pH of around 6 to 6.5.	No	The type of fertiliser has not been looked at
14	Method for seeding is the measuring spoons	Partially	It was discovered during the try it yourself but not looked into after that
15	Max dimensions are 90 x 50 cm	Yes	The size of the product is of 50x85 cm
16	10 trays per level	Yes	There are 10 trays per level

Conclusion

The main objective of this work was to assess the waste of restaurants. A study case was conducted in Skagen Fiskerestaurant wherethe total food waste amounted to 31.5 kg of food, 4.45 kg of plastic packaging for fish, and 4.05 kg of plastic packaging for vegetables per day.

Different directions were explored to completely rethink and reduce the plastic packaging waste and, in the process, stumbled upon designing a vertical garden. In fact, some had already considered it. The lack of space outdoors, time, and knowledge prevented them from attempting it.

The product proposal consists of two units; respectively for micro- and leafy greens, which would allow restaurants to become self-sufficient. The microgreen unit provides a total of 6 kg per week while the leafy green unit provides roughly a total of 4 kg leafy greens per week.

The product proposal was designed based on several interviews, sketches, and concept development rounds. After several iterations, VertiGarden was born. This is a vertical gardening device targeted at restaurants, which not only allows to produce part (if not all) of their micro- and leafy green requirements. But also, allows them to showcase their produce to their clients by becoming part of the dinning's ecosystem. A fresh, ecodesign facilitates the integration of VertiGarden as part of the decoration, while providing literal nutritional value to both customers and the restaurant's identity.

Briefly, restaurants receive a monthly package covering their seeding needs. This progression allows to continuously enjoy a fresh harvest, while germining the next batch of greens. An smartphone app connects restaurant's managers with the VertiGarden platform, which interfaces the microcontroller Arduino in an easy and understandable way. The app tracks the growth progress of the different greens, suggest the kickstart of subsequent batches and provides different consumption statistics to the user. Overall, providing insight regarding periodic consumption, while suggesting growing tips, alerts, enabling ordering seeds, and becoming the information highway between VertiGarden users and us. Information collected from the users facilitates improving the tips, targeting different seeds, and amount of produce to be sent to the restaurants. Furthermore, the app allows multiple users to simultaneously take care of the VertiGarden and its produce. The device automatically waters the greens (via nutrient-film technique), controls lighting and ventilation, ensuring maximum yield. Recent trends favour local food production, specially if ecologic, which motivates clients to spend more. By integrating VertiGarden as part of the restaurant's decoration, the local makes a statement aligned with said values, increasing transparency, and facilitating the brand recognition and prestige from customers.

Leasing seems to be the most interesting business case for restaurants. This results evident from the conducted interviews, which concluded by highlighting the fact that restaurant owners are not ready to invest large sums in purchasing a high-tech product such as VertiGarden. The restauration industry is volatile, obscuring the strategies that owners might envision. Therefore, VertiGarden is leased to the customers for a minimum of 18 months, for a monthly rate of 2000 DKK, which provides immediate monthly savings amounting to 2400 DKK. Such leasing includes replacement cost in case of any malfunctioning of a device. In this context, seed sourcing and growing mediums represent an independent variable expense based on the specific demand.

VertiGarden becomes CO2e-neutral only after approximately 12 weeks of use. Subsequently, the restaurant saves approximately 35 kg of CO2 weekly per VertiGarden device. Additionally, the design of the product allows our company to easily correct minor deficiencies such as obstruction of particular pipes. Lastly, VertiGarden can be dismantled at the end of its life allowing to repurpose individual parts, and recycle the rest.

Overall, VertiGarden constitutes a sustainable choice for those restaurants aiming to highlight the local origin of their produce, while reducing their expenses and waste. Not only is sustainable, but it also results profitable for both restaurants owners and to the leasing company.

Reflection

The thesis project started with a number of wild ideas, such as to create a foldable type of trailer to facilitate maintenance of medium size boats. Lack of realistic incentives for such an idea, motivated the team to pursue alternative products. Subsequently, the group shifted towards private gardeners first, and, finally, to restaurant's waste. Such decision making process consumed a significant amount of time, which forced the team to speed up development from then onwards.

During these past few months, the team has developed its competences within wicked, and ill-defined problems. Nonetheless, the interdisciplinar competences of both team members allowed to enrich the project's process with multitude of techniques inspired by our own particular backgrounds. For instance, the electronics, actuators, app design, and programming on the one hand, and aesthetics, simplicity and pulcritude of the furniture on the other. The group is aware this project might be regarded as out of the ordinary within the MSc of Industrial Design as the focus is on profitability and pragmatism, but we truly believe it contains all key elements of state-of-the-art produc development.

During the process, several questions have been opened but not answered. For example, during the discovery phases of the project, it was found that microgreens do not need fertiliser to grow, however, leafy greens do. There was not any research made throughout the project on what specific type of fertiliser the leafy greens should use for the best growth. The group is just assuming that all fertilisers would work and the information found was very broad like for example the water pH.

Another question that remained unanswered is the personalisation of the product. During the process it was mentioned that this could be a possibility but, this entails extra price and extra CO2e emissions that were not explored.

The group, would have liked to, in general, have more time to develop the more engineering parts further as this is the part of the project they most enjoy. However, as mentioned earlier, the lack of practice to navigate through wicked problems meant that a lot of effort had to be put in there which then took away the energy to do the more interesting parts.

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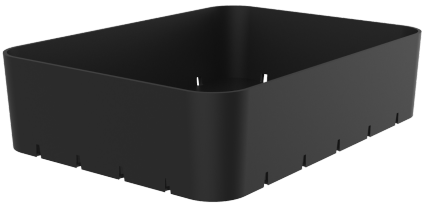
Illustrations list

APPENDIX

APPENDIX COLLECTION
AALBORG UNIVERSITY
SPRING 2023
INDUSTRIAL DESIGN
MSC04-ID12

Eiden Arredondo Harmen
Laura Moreno Huang



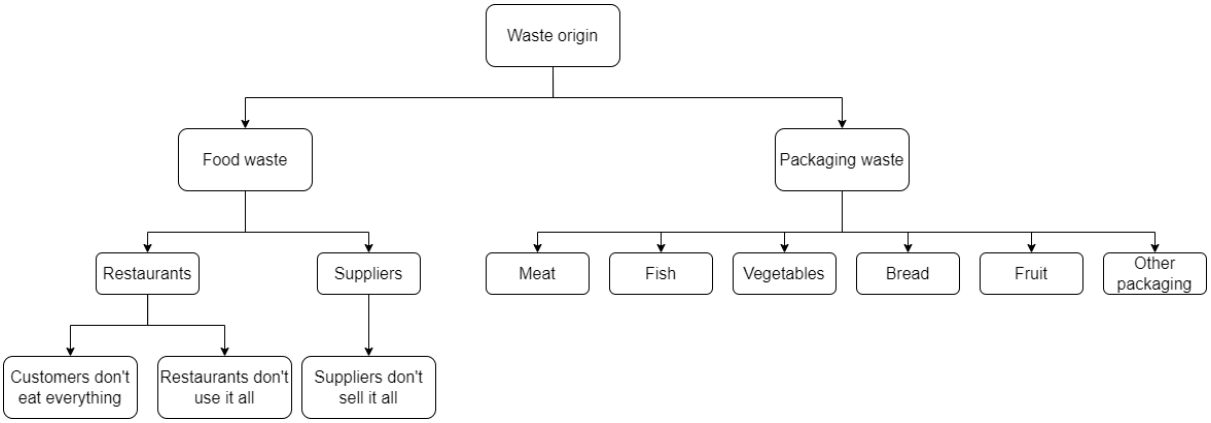
Appendix 01 - Restaurant shadowing

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim with this worksheet is to obtain information from the restaurant as to what amount of waste is produced and from what food category. In this case, a case study is performed on Skagen Fiskerestaurant in Aalborg. Best case scenario would be to be able to obtain numbers from various restaurants in different categories. Because of lack of time on the restaurants behalf, and the trouble that it would cause them, it is only possible to shadow one restaurant. The shadowing method is used to follow around the chefs observing where waste is produced. On top of observing where waste is produced and where it comes from, the aim is also to weigh how much waste is produced. To do this, instead of allowing the chefs to throw out the waste, it is collected and sorted into different piles so they can be measured at the end of the work day.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

Before shadowing:
Some assumptions as to what type of waste is made are done. It is assumed there are 2 main types of waste, food waste and packaging waste. Within packaging waste, it is believed that it is a good idea to sort out what that packaging is used for (meat, fish, vegetables, etc.) during the shadowing so that it is easier to measure the amounts of waste at the end of the day.



The day of the shadowing:
The group is informed that at the end of every workday, Skagen Fiskerestaurant makes an inventory of what they have and will need for the next day so they can order it.
The next day in the morning, the catering company (AB catering used by Skagen Fiskerestaurant) arrives with the supplies (around 11 am):

Once they have arrived, if they have the time the chefs start unpacking the supplies and sorting them into the right fridges already throwing away some packaging. Sometimes, the food might stay out for more than 4 h which means that the food isn't cold anymore and will spoil faster.

These first boxes, which are referred to as "motherboxes" or secondary packaging [1], are made out of cardboard and contain various units of the same product. These are sorted and collected. Then, as the day progresses, the primary packaging [1] gets thrown out too which is also sorted and collected.

At the end of the day, the different piles are weighed to get an idea as to how many Kg of waste there are of each. The reason for this is because targeting the whole waste produced is not realistic and therefore the team wants to target a meaningful part of the waste generated and not focus on a negligible part of the waste. Bellow, images of the waste and of the weight are shown and added up to find the total weight of each pile:

Food waste:

During the day, 7 bags of food waste were collected, each one weighing approximately 4.5Kg. This means that in total 31.5Kg of food waste is produced in one day. This can be seen in the table below:

Food waste	
x7	4,5
Total	31,5

Packaging waste for meat:

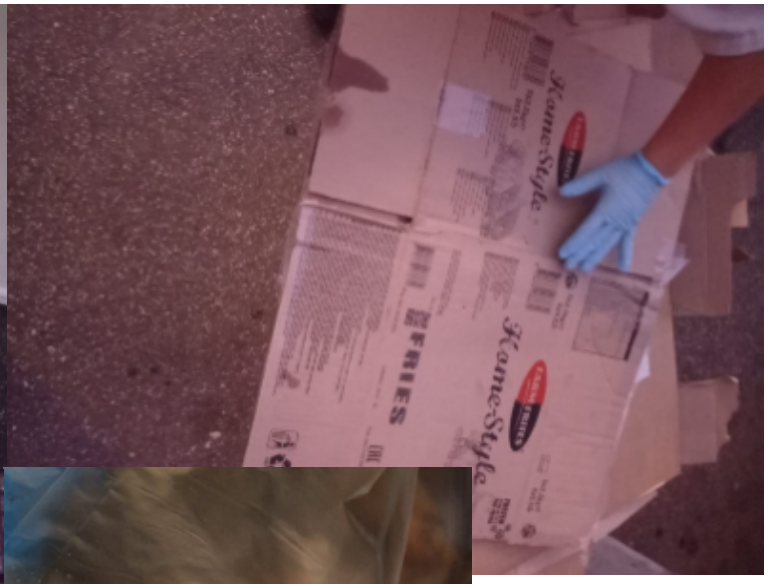
During the day, it was observed that the packing for the meat was simply put into the common trash because it is “contaminated” with the blood from the meat and they didn’t want to clean out such small packaging. So numbers for this specific category weren’t obtained.

Packaging waste for fish and seafood:

During the day, 6 flamingo boxes were collected together with other packaging for the fish. The table below shows the weight and the total sum:

Fish waste and sea food	
	1,609
x6	0,391
	0,495
Total	4,450

Packaging waste for vegetables:



During the day, a lot of different packaging for the vegetables is collected and weighed. The table below shows the different weights and the total sum.

Vegetables waste	
	2,126
	0,179
	0,380
	0,323
	0,084
	0,296
	0,265
x2	0,2

Packaging waste for bread:

During the day it is observed that there is no packaging for the bread that is thrown out. The reason for this is that they use a reusable container in which they get the bread from a next door bakery.

Packaging waste for fruit:

During the day it is observed that there was no packaging for the fruit that was thrown out. The reason for this is that the fruit ordered all comes in one mother box packaging, so no primary packaging, and is not used very often meaning that the packaging is still needed for the fruit that will remain in the fridge for the following days.

Packaging waste for others:

During the day, the packaging of various other small categories like eggs and cheese is collected and weighed. The table below shows the different weights and the total sum

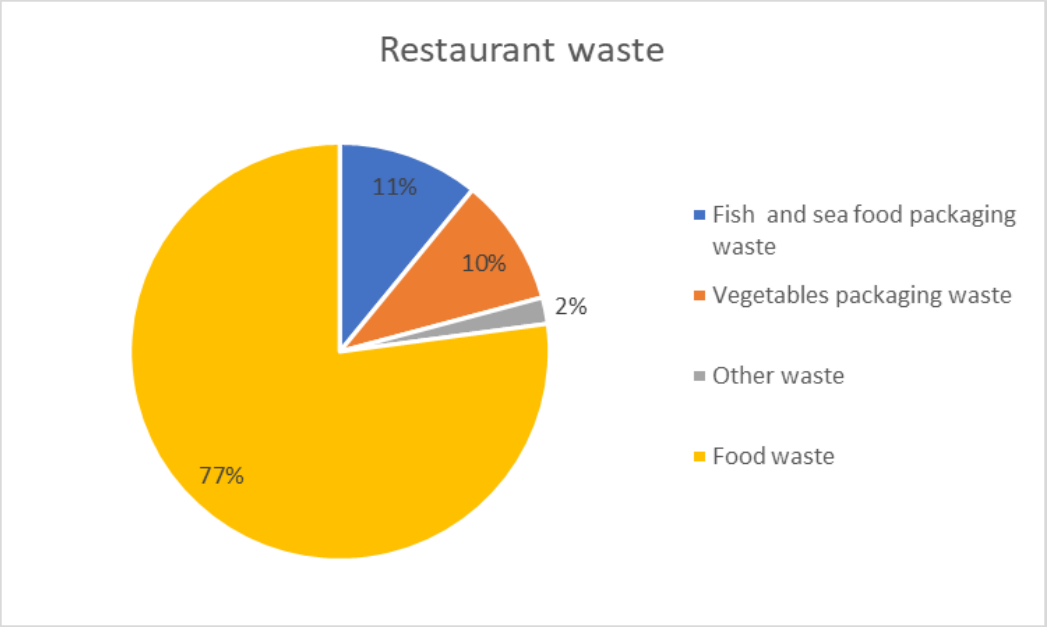
Other waste	
	0,469
	0,367
Total	**0,836**

Evaluate

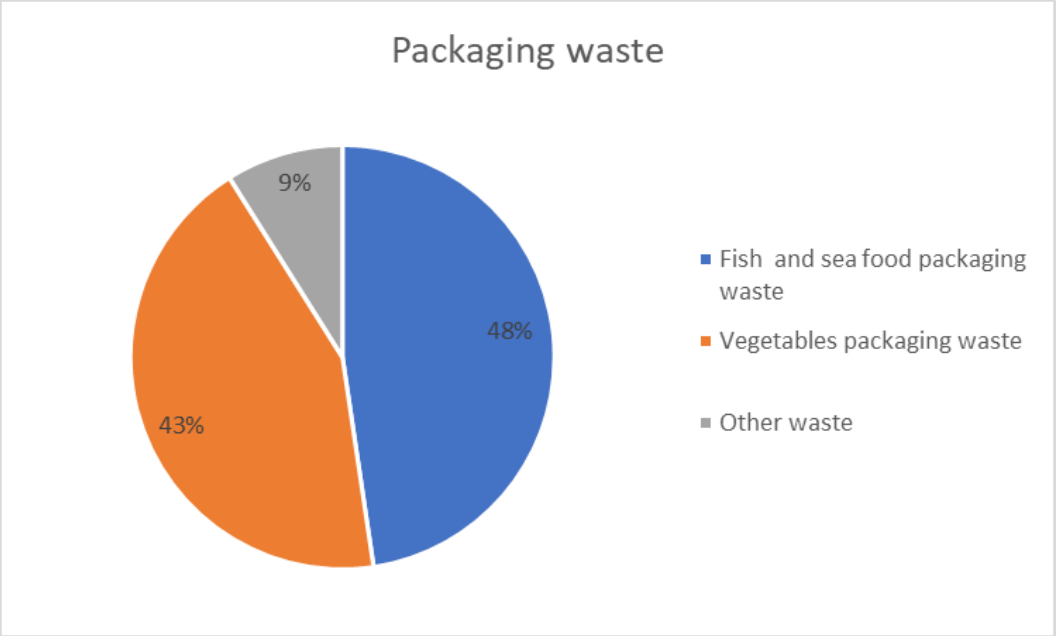
Summarise and evaluation. Did the activity meet the objectives and to what extent?
How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?

Shadowing allowed the group to observe and measure where the different waste in the restaurant comes from. This was collected and two pie charts were made, one for total waste, and one for only packaging waste. The activity, at the same time, accepted and rejected some of the assumptions made before the shadowing. Some of the assumptions that there would be packaging for bread were dismissed since they reuse some plastic boxed. Other assumptions like there being a lot of food waste and the different types of waste were proved to be correct.

In the pie chart below, it is possible to see that in this case, 77% of the waste comes from food waste. This amounts to over 3/4ths of the total waste. The fish and seafood packaging waste is 11% of the total waste in the restaurants and the vegetable packaging waste is 10%.



When looking at only packaging waste, it is possible to see from the pie chart below that 48% of the packaging waste comes from fish and 43% comes from the vegetable packaging waste.



With this data, it is possible to see that the biggest impact can be made in the following three areas:

- Food waste
- Fish and seafood
- Vegetables

When analysing this data it needs to be taken into account that Skagen is a chain fish restaurant, therefore it might generate more waste in this category. As mentioned before, having more case studies would be ideal.

Reflection

What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?

Thanks to this activity, numbers for the weight of the different piles that were made were obtained. Furthermore, it was possible to obtain a contact for AB catering so that an analysis of the supply chain could be made in a thorough manner.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

[1]: https://www.oliverinc.com/blog/what-is-primary-vs.-secondary-packaging#:~:text=Primary%20packaging%20separates%20your%20product,protecting%20and%20promoting%20your%20brand&text=As%20the%20all%2Dencompassing%20term%20suggests%2C%20packaging%20serves%20multiple%20purposes. (06/04/2023)

Appendix 02 - AB catering interview, understanding the supply chain

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim with this worksheet is to prepare a structured interview. This interview will take place over the phone since it has not been possible to organise a face-to-face meeting. During the shadowing activity from Appendix xx, a number was obtained from the food supply company, AB Catering. This number belongs to Kim Kristensen, the boss of the driving department.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

To organise the structured interview some questions are prepared before the phone call so that the answers that the group is looking for can be found.

To get an idea of what happens in the supply chain, the following questions are written down.

- **When they obtain the food:**
    - **Where are your main suppliers from?**
    - **What packaging do you receive the supplies in?**
    - **Do your suppliers make the food or do they get it delivered from somewhere else?**
- **When the food is stored:**
    - **How is the food stored?**
    - **Do you unpack anything or is it stored as it comes?**
    - **How long do you store the supplies before sending them out to restaurants?**
    - **How does it work when you receive an order from a restaurant? Is there any repacking, sorting, etc?**
    - **What is the most used packaging material?**
    - **Do you reuse any packaging?**
    - **If so, how does that work?**
- **Would it be possible to get access to the website to obtain information such as prices, origin of the product, weight, etc?**
- **Any further comments?**

With these questions done, the next step is to call Kim for the interview and write down the answers so that a better idea of how the supply chain works can be obtained.

- **When they obtain the food:**
    - **Where are your main suppliers from?**

Most of our suppliers are from outside Denmark, mainly in southern Europe (Spain, Italy, France).

- **What packaging do you receive the supplies in?**

The product comes in different packaging depending on the supplier. They mostly come in big cardboard boxes (mother box) and, if needed, their individual plastic packaging.

- **Do your suppliers make the food or do they get it delivered from somewhere else?**

It depends, some suppliers make their own produce, others collect different produce from another supplier and give them to us.

- **When the food is stored:**
  - **How is the food stored?**

The food is stored on shelves in the boxes they come in.

- **Do you unpack anything or is it stored as it comes?**

We mainly unwrap the boxes from the plastic wrapping they come in on the pallets.

- **How long do you store the supplies before sending them out to restaurants?**

It is mainly stored for a maximum of 2 days

- **How does it work when you receive an order from a restaurant? Is there any repacking, sorting, etc?**

It is like a supermarket, we collect the food according to the restaurant's demand and then repack it. We mostly use cardboard boxes but sometimes have to use plastic bags so that, for example, the lemons are not loose.

- **What is the most used packaging material?**

Cardboard. We try to use the cardboard boxes the products come in but sometimes we have to add our own or use some smaller ones.

- **Do you reuse any packaging?**

We have what we call “green boxes”, these are reused once the restaurant hands them back.

- **If so, how does that work?**

We have a partnership with the company that makes and is in charge of these “green boxes”. The restaurants are given the option to choose the use of these “green boxes”. To do this, they have to deposit 29 dkk that they then get back once they return the boxes. For us this means that we need to retrieve them and wash them before next use. This has a total cost of 5kk for us.

- **Would it be possible to get access to the website to obtain information such as prices, origin of the product, weight, etc?**

I cannot give you access to the website because I am not in charge of it. But you can call Allan at +45 xxxxxxxx and maybe he can help you.

- **Any further comments?**

In the future, it could be possible to implement the “green box” system in the entire process, from the producers to the restaurants. This will require an extra cost which, in this case, AB catering would assume, considering that there is a new law in the coming demanding more sustainability.

We have noticed that restaurants in Aarhus demand more use of green boxes as their Kommune (municipality) supports more sustainable options than in Aalborg.

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

Thanks to this activity it is possible to understand more in-depth the whole supply chain process and further possible waste sources. At the same time, it helps to find out the different origins of certain products, their weight, and their price. This will help to figure out some more precise quantities that the restaurants need during the week.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

Currently, the group is waiting for an answer from Allan to see if it is possible to get access to the webpage. A face-to-face meeting would have been preferred over a phone interview but sadly that was not a possibility at the time.

Appendix 03 - Current solutions for tackling food waste

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The objective of this worksheet is to explore the different solutions already in place targeting the problem of food waste. The main focus will be on finding solutions that are being used in Denmark as it is the focus area on which the thesis is taking place.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

To good to go:

Too Good To Go is a company with a mission to reduce food waste and fight climate change. Their values include sustainability, social responsibility, and innovation. They believe that food waste is not only an environmental issue but also a social and ethical one, and they are committed to finding solutions to address it.

The company's approach to achieving their mission is through their mobile app-based service that connects consumers with local food establishments that have un sold or surplus food,at a much lower price than normal.The food on the app is priced at one-third its original price. By doing so, they aim to reduce food waste and encourage a more sustainable and circular food system. Their goal is to make sure that no edible food goes to waste, and that resources are used in a more responsible way.

Overall, Too Good To Go is driven by the belief that everyone has a role to play in r**educing food waste and creating a more sustainable future**. Their approach is to **empower individuals and businesses to take action, and to inspire others to join the movement.**

Wolt:

Wolt is a technology company that offers an app-based food delivery service. Their core values include a focus on quality, convenience, and innovation. They aim to provide high-quality food delivery services that are both convenient and innovative.

To achieve this, Wolt has developed an app that enables customers to order food from local restaurants and have it delivered to their doorstep. The company collaborates with a network of restaurants to provide customers with a wide range of food options, including local favourites and international cuisines.

Wolt's main objective is to transform the food delivery industry by offering a seamless and user-friendly service to customers. They are committed to partnering with local businesses and utilising technology to streamline the delivery process and enhance

the customer experience. Additionally, Wolt is dedicated to reducing their environmental impact by using sustainable delivery methods and minimising waste.

In summary, Wolt strives to make food delivery easy, convenient, and accessible to everyone. By working with local businesses and leveraging technology, they aim to **provide a top-quality food delivery** experience for both customers and restaurants **while also minimising their environmental footprint**

Foodop:

Is a Danish new layer of technology (Madspildsplatformen) that helps commercial kitchens measure food waste and guest preferences, and then use these insights to improve future menus in terms of e.g., quantities, guest preferences and the environmental footprint.

They do so through a **menu planning platform** that is enriched by data from scales that are placed under all dishes and organic bins in food servings. From there, the scales automatically **measure consumption and leftovers for each dish**.
They focused mainly on the UN goals : 2, 12, 13

WeFood:

Is a Danish **grocery store** that sells surplus food **donated by supermarkets**, wholesalers, and producers. The store also donates surplus food for animal feed and composting

In 2016, Folkekirkens Nødhjælp opened the doors to Wefood, Denmark's first store that sells products with damaged packaging, incorrect labelling, expired shelf life and seasonal products.

The profits from the Wefood stores go to people in need.

When you fill the shopping basket with goods from Wefood, you are also supporting the Norwegian Church Aid's climate work and development projects in countries such as Cambodia, Ethiopia and Zimbabwe. You **reduce food waste** , while **fighting hunger** and s**upporting new solutions** in the world's poorest communities.

Giving leftovers to farms:

According to one of the chefs from Skagen Fiskerestaurant, some farms make **partnerships with restaurants** so they receive the surplus food or leftovers to feed the animals or let it compost the fields.

From interviews that the group conducted, it was found that restaurants like Nordur or Alimentum already have this kind of partnership with farms.During the interviews it was also found that some of the restaurants have their own garden or are in the process of having one like Ubat /Tabu here in Aalborg or Noma in Copenhagen that closed down.

Overall, these companies in Denmark are all working to reduce food waste by finding new ways to repurpose surplus food, including donating it for animal feed or composting.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

https://foodop.dk/en/less-food-waste/
https://www.noedhjaelp.dk/madspild
https://wolt.com/en/dnk
https://www.toogoodtogo.com/da

Appendix 04 - CO2e emissions from Shadowing

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to find out how much CO2e emissions there are in the current supply chain. SimaProDemo software will be used to calculate the CO2e emissions of manufacturing the packaging and transporting it. Thanks to the interview in App xx, it is possible to roughly estimate the transportation distances between packaging suppliers, food suppliers, and restaurants.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

In order to do these calculations, some assumptions and limitations are necessary:

Assumptions:

- All packaging is manufactured in Europe:
    - Soft plastic: Amcor group in Poland
    - Hard plastic: Amcor group in Poland
    - Flamingo: BASF SE. in Germany
    - Cardboard: Akomex group in Poland
- All transportation is done by truck
    - Except from Kenya, here it is assumed that it goes from Kenya to Spain by container ship and then lorry from Spain to Denmark. For this, it is also assumed that the packaging manufacturer will be somewhere in Kenya.
    - Except from Israel, here it is assumed that it from from Israel to Italy by container ship and then lorry from Italy to Denmark. For this, it is also assumed that the packaging manufacturer will be somewhere in Israel.
    - As Amcor group provides both hard and soft plastics, if they are needed in the same country the transport will only be counted one time.
    - Once the food is in the truck, it is assumed that the trucks will be refrigerated so that it stays as fresh as possible.
- The calculations performed are for the day that the shadowing was done and therefore will vary from day to day according to the demand in the restaurant.

Limitations:

- The exact position of the packaging suppliers and food suppliers is not known. Because of this, the countries will be considered as points on the map and the exact distance between the different countries is not taken into account. This means that when the packaging is transported to Denmark for example, the distance from the warehouse with the packaging to the food suppliers is not taken into account. Likewise, the distance between the food suppliers to the restaurants is also not taken into account.

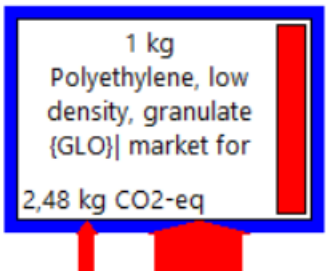
- The calculations are performed with the numbers available. This means that the amount of plastic, cardboard, and flamingo manufactured are the waste weights that were obtained from the shadowing in the restaurant (Appx. 01). There are no numbers available as to how much material (packaging or food) is being transported from the different origins to the restaurant.
- The libraries used in SimaProDemo collect information from all around Europe (at least the selected option for calculations) and average the results in order to be able to calculate the emissions.
- Because of the big uncertainties to calculate the emissions, the worst case scenario is used where there is no information available. This means that for example, the Akomex group does not have a centralised warehouse to store packaging and therefore has to send it to the different countries individually. On the same principle, because it is unknown if the food suppliers within one same county are the same, it is assumed they are not.
- The EUROpallet and plastic film wrapping that is used to protect cargo during transportation is neglected in these calculations.

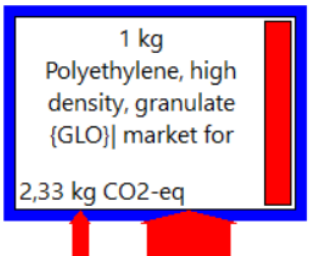
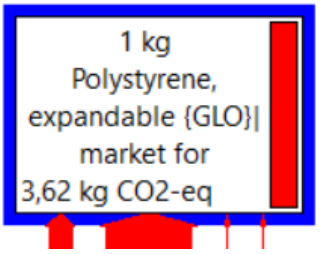
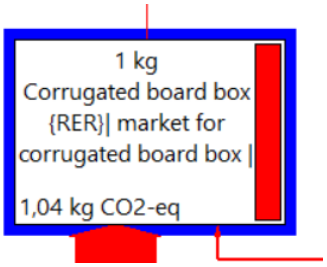
Data gathered:

- Fish (locally sourced):
    - Soft plastic: 0.495Kg
    - Cardboard: 1.609Kg
    - Flamingo: 2.346Kg
- Vegetables (sourced from 7 different countries):
    - Soft plastic: 0.38Kg
    - Hard plastic: 0.586Kg
    - Cardboard: 2.887Kg

Calculations:

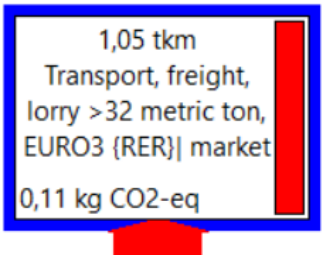
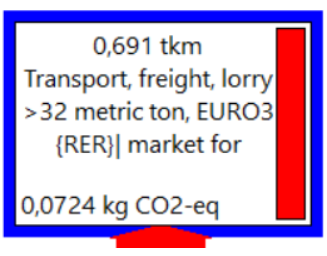
Step 1: The first step is to calculate the CO2e emissions of the different materials. Here the emissions are calculated first per Kg of material. The SimaPro software calculates the emissions for the production of these materials including the waste, electricity, raw material, etc. Once done, it is possible to calculate the emissions for the specific amounts in the restaurants.

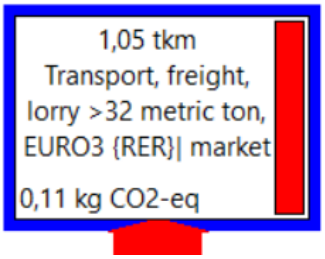
Soft plastic		For fish this means that the CO2e emissions are: **1.23Kg of CO2e.** For vegetables this means that the CO2e emissions are: **0.94Kg of CO2e.**

Hard plastic		For vegetables this means that the CO2e emissions are: **1.37Kg of CO2e.**
Flamingo		For fish this means that the CO2e emissions are: **8.49Kg of CO2e.**
Cardboard		For fish this means that the CO2e emissions are: **1.67Kg of CO2e**. For the vegetables, this means that the CO2e emissions are: **3.01Kg of CO2e**.

Step 2: The second step is to calculate the emissions of the transport from the packaging suppliers to the food suppliers and then to the restaurant. These calculations assume the different transport modes' capacities.

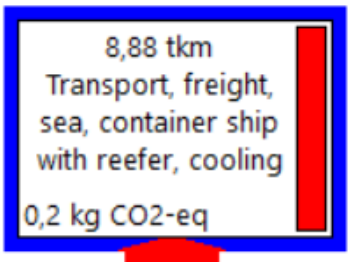
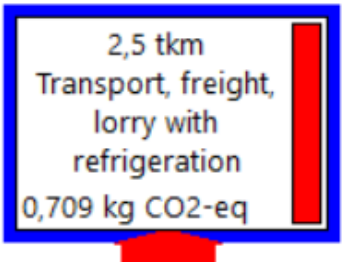
Fish: As mentioned in the assumptions, the fish is sourced locally meaning that all the packaging will go straight to Denmark.

Soft plastic - Poland to Denmark - 1049Km		The transportation for the soft plastic from Poland to Denmark emits **0.11Kg of CO2e.**
Flamingo - Germany to Denmark - 691Km		The transportation for the soft plastic from Germany to Denmark emits **0.0724Kg of CO2e.**

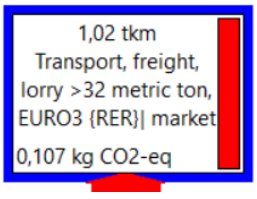
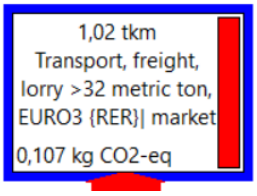
Cardboard - Poland to Denmark - 1049Km		The transportation for the soft plastic from Poland to Denmark emits **0.11Kg of CO2e.**

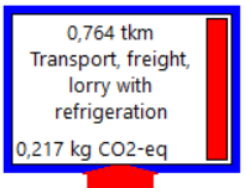
Vegetables: If soft and hard plastic are needed in the same country, the transport will only be counted once. As mentioned, once the food is in the truck, a refrigerated truck will be used, likewise, once the food is in the truck, all the packaging travels together.

Kenya to Denmark:

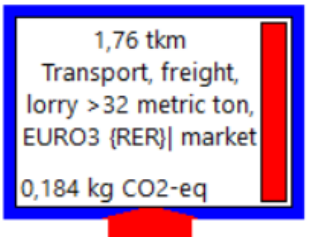
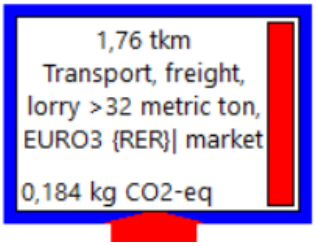
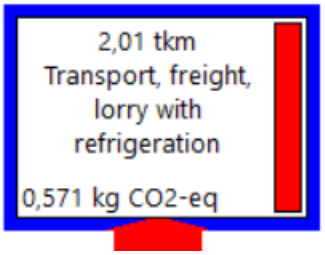
Kenya to Spain - 8879Km		With this, it is possible to calculate the total emissions. Because there are three different products going from Kenya to Denmark, the total transport is multiplied by three. Total emissions = (0.2+0.709)*3 = **2.727Kg of CO2e.**
Spain to Denmark - 2496Km		

Netherlands to Denmark:

Soft plastic - Poland to Netherlands - 1023Km		With this, it is possible to calculate the total emissions. Because there are three different products going from the Netherlands to Denmark, the total transport is multiplied by three. Total emissions = (0.107+0.107+0.217)*3 = **1.293Kg of CO2e.**
Cardboard - Poland to Netherlands - 1023Km		

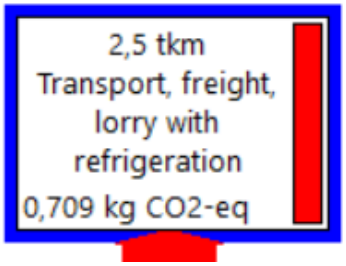
Netherlands to Denmark - 764Km		

Italy to Denmark:

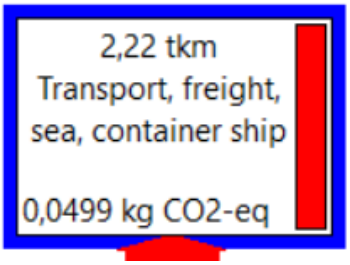
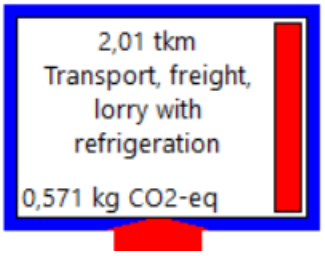
Soft plastic - Poland to Italy - 1755Km		With this, it is possible to calculate the total emissions. Because there are five different products going from Italy to Denmark, the total transport is multiplied by five. Total emissions = (0.184+0.184+0.571)*5 = **4.695Kg of CO2e.**
Cardboard - Poland to Italy - 1755Km		
Italy to Denmark - 2010Km		

Spain to Denmark:

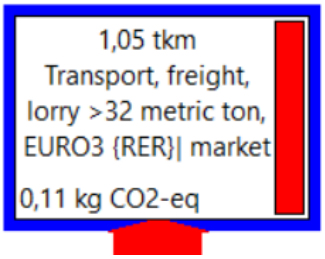
Soft plastic - Poland to Spain - 2717Km		With this, it is possible to calculate the total emissions. Because there are three different products going from Italy to Denmark, the total transport is multiplied by three. Total emissions = (0.285+0.285+0.709)*3 =

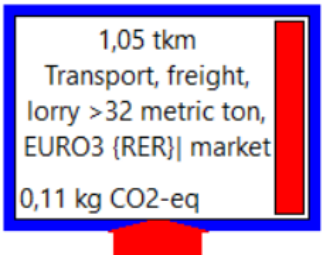
Cardboard - Poland to Spain - 2717Km		**3.837Kg of CO2e.**
Spain to Denmark - 2496Km		

Israel to Denmark:

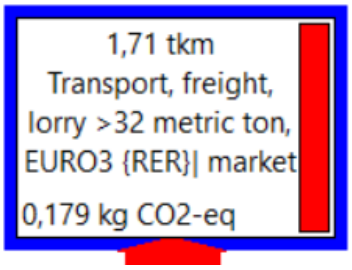
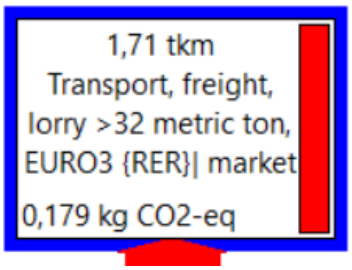
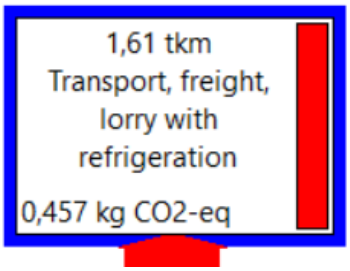
Israel to Italy - 2221Km		With this, it is possible to calculate the total emissions. Because there is only one product going from Israel to Denmark, the total transport is simply the sum of the ship from Israel to Italy and the truck from Italy to Denmark. Total emissions = 0.0499+0.571 = **0.62Kg of CO2e.**
Italy to Denmark - 2010Km		

Poland to Denmark:

Soft and hard plastic - Poland to Denmark - 1049Km		With this, it is possible to calculate the total emissions. Because there are seven different products being produced in Denmark, the total transport is multiplied by seven. Total emissions = (0.11+0.11)*7 = **1.54Kg of CO2e.**

Cardboard - Poland to Denmark - 1049Km		

France to Denmark:

Soft plastic - Poland to France - 1708Km		With this, it is possible to calculate the total emissions. Because there is only one product going from France to Denmark, the total transport is simply the sum of the trucks from Poland to France and then the truck from France to Denmark Total emissions = 0.179+0.179+0.457 = **0.815Kg of CO2e.**
Cardboard - Poland to France - 1708Km		
France to Denmark - 1607Km		

<u>Step 3:</u> The final step is to add together all the different emissions to find out the total CO2e emissions. This is done for both the fish and the vegetables so that the CO2e emissions can be compared between them.

Total emissions fish = Emissions soft plastic + Emissions flamingo + Emissions cardboard + Emissions transport = 1.23 + 8.49 + 1.67 + 0.11 + 0.0724 + 0.11 = **11.68Kg of CO2e.**

Total emissions vegetables = Emissions soft plastic + Emissions hard plastic + Emissions cardboard + Emissions transport = 0.94 + 1.37 + 3.01 + 2.727 + 1.293 + 4.695 + 3.837 + 0.62 + 1.54 + 0.815 = **20.847Kg of CO2e.**

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

With this activity it has been possible to estimate the emissions from packaging and transport for both the fish and the vegetables. From this it is possible to see that the emissions surrounding the vegetables is much higher than that of the fish. For the vegetables, most of the emissions come from the transport whereas most of the emissions for the fish come from the packaging. The best way to reduce the emissions for the vegetables is to cut down on emissions from transport meaning that the production should be closer to or in Denmark. The best way of reducing emissions for the fish would be to use a different material for the packaging or to use a reusable one.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

With this worksheet, it is possible to see the importance of reducing not only the manufacturing of the products but most importantly the transport of these as it accounts for a greater value in CO2e emissions.

These calculations are approximations as there are many assumptions and limitations that have been used to obtain these numbers. It is of course important to notice that if more products are being transported at once, the CO2e emissions that correspond to a single unit are decreased and this is why the placement of the products and the packaging for these is so important in the containers. In a nutshell, space efficiency is necessary.

These calculations also assume the material used for the packaging is new and not recycled which would decrease the manufacturing process significantly.

Appendix 05 - Data gathered from restaurant interviews

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim with this worksheet is to gather restaurant info and numbers so that the group can get in contact with them.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

- ***Cafe/ sandwiches***
    - **Bagtanker:**
        - **Location:** Himmerlandsvej 59, 9520 Skørping
        - **Status:** Teis (owner) — Søren and Hening Visit and interview conducted
        - **Phone number:** 20 80 00 33
        - heidimynsterlisby@ gmail.com
        - Sustainable conscious
    - Info obtained
        - Worries
            - Already with a similar solution but not happy with it as they had to close it down because of the flies
            - They will not have soil in the new solution
            - Its a big installation, might not have space
            - The purple ligths makes it seem that you are growing a different type of greens
        - Time
            - With soil it takes them 4 trays 15 mins
            - 2h a week as this is new
        - What they plant
            - Peas, this is the preferred option
            - Karse, too small they don't use that much
            - Sunflower, they are a bit messy as the seed shell gets stuck on the plant , this also do might have more waste as they don't keep fresh for too long once they grow , if not harvested they die.
            - Sometimes they have herbs
            - Could be nice to have flowers ,cabbadge, broccoli , leafy greens. Implement the use of super foods.as they have more vitamins in such littel space.
        - Good to have
            - Automatic (Right now they water it by touching the soil)
            - Could be an experience for the costumers
            - They are 3 different persons taking care of the garden

        - They don't use fertilizers or additional nutrients
        - Display the information
        - Planting diary ?
        - Guidelines, reminders
        - Description of taste of the Mg
    - Opinions
        - She prefers to buy local foods as is more sustainable
        - Selfgrow taste better (better quality)
        - Restaurants costumers really enjoy and they ask about it.
- **Pennylane:**
    - **Location:** Skipper Clements Gade 1a, 9000 Aalborg
    - **Status:** Contacted, interview conducted
    - **Phone number: FB**
- Info obtained
    - Worries
        - They will not have soil
        - Its a big installation, might not have space
        - A stand like that will not look very appealing, when half of the herbs have been cut down, if it is in public display.
    - Time
        - 0-1h per week
    - What they use
        - Pea shoots, snap pea sprouts, watercress, meadow sorrel {sic}, dill, chervil, nasturtium, different flowers when in season.
        - Lots of herbs
        - In total, 1,5 to 3 kgs, depending on the week.
        - 400dkk -500dkk – 900dkk-1000dkk depending on the week.
        - When needed, we can get most day to day, and some within two days. Though we'll get the different things once or twice a week.
        - Added to excel sheet
    - Opinion:
        - There hasn't been any serious products like this introduced to the DK market, as far as I know. And having been doing a small herb-garden for a year, for a restaurant, it is quite work-demanding, by keeping correct watering, sun/shadow ratio, re-sowing etc.
        - The expense, the time and managing and possible unused produce from such a product, will keep me from getting one. Together with the idea of where to put it, within regulations, together with the everlasting issue of not having enough space for everything.
- **Cafe pace:**
    - **Location:** Boulebarden, 9000 Aalborg
    - **Status:** Concated, we sent them an email to cafe@cafepeace.dk, Not successful
    - **Phone number: 70 70 71 03**

- ***Eco / Veg***
    - **Alimentum:**
        - **Location:** Lokegade 23 , Aalborg
        - **Status:** Interview conducted
        - **Phone number:** 93913767
    - Info obtained
        - Worries
            - They have their own garden (they can grow all year due to weather)
        - Time
            - 1h-2h per week
        - What they use
            - They don't use micro greens
        - Opinion:
            - They think its a really interesting project and fits with their DNA also this way
            - They could grow vegetables all year around

    - **UBAT/ TABU:(wed-thursday)**
        - **Location:** Vesterå 5
        - **Status:** Intervie conducted
        - **Phone number:** 88196058
        - 80 costumers per week
    - Info obtained
        - Worries
            - They have their own garden (they can grow all year due to weather)
        - Time
            - 1h-2h per week
            - Closed 3 days in a arrow
        - What they use
            - Cress (different types)
            - Seasonal vegetables they choose depending on the price
            - AB catering client
            - 3kg of microgreens
            - Tyr to order local
            - Oder 2 times a week
            - Spend 160 kg per kg
            - Lots of herbs
        - Opinion:
            - Could look nice in the restaurant

    - **Mest, restaurant at the AKKC: https://madmed-mest.dk/**
        - **Location:** Europa plads 4 (AKKC)
        - **Status:** Contacted, email sent, Not succesfull
        - **Phone number: +45 99 35 55 90**
- ***Luxury***

- **Skagen fiske restaurant:**
  - **Location:** Budofil plads, 9000 Aalborg
  - **Status:** Interview and shadowing done
  - **Phone number: FB**
- Info obtained
  - Worries
    - They don't use so much vegetables
  - Time
    - 1h per week
  - What they use
    - Karse, peashoots
    - Leafy greens mizuna …
  - Opinion:
    - They are a chain and a fish restaurant so they don't really care about sustainability

- **Kunsten museum (Brasserie Kunsten):**
  - **Location:** Kong Christians Alle 50, 9000 Aalborg
  - **Status:** Still needing to contact some of the employees there
  - **Phone number:** 99 82 41 00
- Info obtained
  - Worries
    - Kids touching it
  - Time
    - 3h-4h per week
  - What they use
    - Fresh herbs (parsley, rosemary, dill) depedns what they can get fresh
    - 6/5 different leafy greens already pre cut
    - Order every day or every other day aporxx 1 kg a week.
  - Opinion:
    - They think its a really interesting project and fits with their DNA also this way
    - They could grow vegetables all year around
    - Its nice that clients can see it
    - They have empty or more calm moments during the day were they can put to use in the vertical garden
- **Aktuel:**
  - **Location:** budofil plads
  - **Status:** Interview conducted
  - **Phone number**: 98125050
- Info obtained
  - Worries
    - They received their MG from Druen a small company, very flexible then can deliver even in the same day

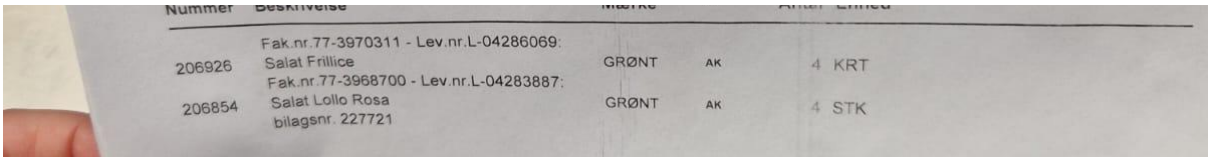
            - Close to 0 waste 70% order on the day
        - Time
            - 1h-2h per week
        - What they use
            - All types of greens they change with the season
            - Not a fixed order, they try to minimize waste so they order inly what they need
        - Opinion:
            - They like the idea and can see it implemented
            - Thye also used vacuum packed and flamingo boxes

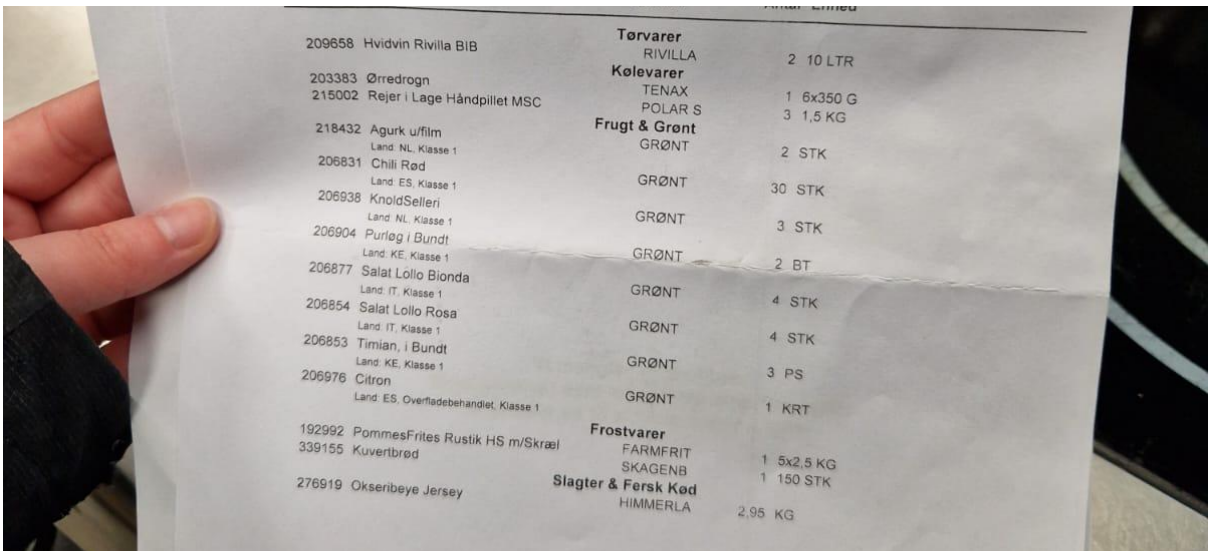
- **<u>Hos Henius :</u>**
    - **Location:** Slotsgade 33, 9000 Aalborg
    - **Status:** Interview conducted, tash was not able to gather
    - **Phone number:** 99 82 41 00
    -
- Info obtained
    - Worries
        - Sacerd of regulations
        - There is way to much plastic were there is no needed
    - Time
        - 1h-2h per week
    - What they use
        - Karse , peashoots, chinarose, kale, chives, dill, persille
    - Opinion:
        - They cant give us their trash
    -
- **<u>La locanda :</u>**
    - **Location:** Slotsgade 33, 9000 Aalborg
    - **Status:** Interview conducted, tash was not able to gather
    - **Phone number:** 81361656 francesco

- Info obtained
    - Worries
        - Sacerd of regulations
        - There is way to much plastic were there is no needed
    - Time
        - 1h-2h per week
    - What they use
        - Karse , peashoots, chives, dill, persille ,basil. Amaretto ,acetosella
    - Opinion:
        - He has experience with this and says that the hardest part is sprouting.
        - Sees lots of potential on out project

	Karse	Pea shoot	Different kinds of cress	Dild	Chives	Parsley	Basil	estragon
Tabu/ ubat			3					
Skagen fiske restaurant	1	0,5		2	0,5	2		2
Pennylane	0,2			0,15		2	8	
Den bette krø	2			1,2	0,8	0,9		
Henius	1	1		3	1,2			
Nordur	1	1						

	Karse	Pea shoot	Different kinds of cress			
1kg	71,8	260	160			
Tabu/ ubat	0	0	480			**excl transport**
Skagen fiske restaurant	71,8	130	0			
Pennylane	14,36	0	0			
Den bette krø	143,6	0	0			
Henius	71,8	260	0			
Nordur	0	0	187,5			
Monthly				Total		
Tabu/ ubat	0	0	1920	1920		5753,8
Skagen fiske restaurant	287,2	520	0	807,2		1150,76
Pennylane	57,44	0	0	57,44		
Den bette krø	574,4	0	0	574,4		
Henius	287,2	1040	0	1327,2		
Nordur	0	0	1125	1125		





Microgreens					kr 799		
Karse	500	26,4	4	kr 106			
Aerte skuld	500	99,79	4	kr 399			
Affila	1000	132	2	kr 264			
China rose	100	15,18	2	kr 30			
Salad				kr 0	kr 388		
Spinach	500	46,2	4	kr 185			
Mizuna	500	52,8	1	kr 53			
lollo bionda	1	12,54	4	kr 50			
lollo rosa	1	12,54	4	kr 50			
Frillice	1	12,54	4	kr 50			
Roots				kr 0	kr 551		
Selleri	1	11,14	3	kr 33			
Porrer	1	23,1	2,5	kr 58			
Asparragus	500	34,32	2	kr 69			
Potatoes	7000	101,64	1	kr 102			
Radish	121	4,95	4	kr 20			
Escalion	180	6,02	28	kr 167			
Danish onion	10000	89,1	1	kr 89			
Carrots	5000	13,85	1	kr 14			
Herbs					kr 317		
Estragon	50	14,19	3	kr 43			
Dill	150	16,24	3	kr 49			
Rosemary	50	15	3	kr 45			
Mllise	50	19,8	1	kr 20			
Koriander	50	13,04	3	kr 39			
kOrvel	50	14,19	3	kr 43			
Persille	200	15,84	5	kr 79			
Fruit					kr 164		
Agurk	1	5,84	2	kr 12			
Chili	30	1,98	30	kr 59			
Citron	1	3,1	30	kr 93			
						kr 2.220	

Appendix 06 - Restaurant categories

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to find out where there is a need or use of the product and what environment and surroundings could be placed , this way it is studied and taken into account when designing. To find this out several different types of restaurant are interviewed and visited. This will help us define some design parameters and also develop part of the business case.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

- ***Cafe/ sandwiches***

  In this category the clients are not so conscious of the food quality nor the waste as this types of restaurant clients mostly go to socialize and is something casual, therefore it is not in the restaurants priorities, they pay more attention to the decoration and ambient created + bread quality.

  - **Bagtanker:**
    - Bakery in skorping,mostly sells sour dough and pastries but functions like a coffee shop as its place next to a sportenter with sports fields, most of their costumers take it to go or stay for a short time, they have a big open space with a long wooden and 4 - 2 persons tables, they have a big area were our product could be place, right now it has decorative plants.

  - **Pennylane:**
    - Restaurant cafe and bakery, the main base of Penny lane is to create a cozy but crowded environment, making you feel like in a fancy livingroom. The interior place is crowded and there is no current space available.
  - **Cafe pace:**
    - Cafeteria restaurant,they open until late serves all types of meals, mostly easy to preparer not much cooking required. 2 floor dining area with couches, currently there is no space they will have to take out some table or install something on the walls.

- ***Eco / Veg***

  In this category the clients are more conciuois of what they eat and the quality of the products used, additionally they are more inclined to care for sustainability and wate reduction. The demand of greens in this category tends to be a big amount.

  - **Alimentum:**
    - The restaurant serves dishes for lunch an dinner, they are aslo categorize as a fine dining restaurant. The restaurant it self cares a lot about sustainavility and has make it one of their selling points as they have Lille Østergaard, an organic farm located near Brønderslev in Vendsyssel. The farm is a strong

collaboration between farmer and restaurant, this way most of thei produce is made local and in a sustainable way .
The restaurant is small with 10 small tables, there is not so much space available.

- **UBAT/ TABU:(wed-thursday)**
  - High end restaurant with two separate eating halls UBAT(Vegetarian and vegan) and TABU which they serv all types of food. Their dishes are elegant and high complex recipes. Their costumers go there for the food quality but also the experience.
    There could be some space found as the are is quite spacious.

- **Mest, restaurant at the AKKC: https://madmed-mest.dk/**
  - Normal danish traditional food , sometimes they cook for events and provide katering. They don't use many vegetable on their dishs.

- ***Luxury (Fine dining)***
  - **Skagen fiske restaurant:**
    - Fish and sea food chain, sea food it self is a luxury type of plate, most of the clients go there for the quality of the food and not so much for the experience as this type of food it is not usually found nor cooked at home. They have 2 walk in fridges and there could be space for our type of product, triki part would be fitting it in to the environment. Sustainalvity is not one of the priorities for the restaurant.

  - **Kunsten museum (Brasserie Kunsten):**
    - Cafeteria and familly restaurant, most of their costumers come to see the museum or do a workshop and then stay for lunch or dinner. The food they serv is leanign to simple such as pizza and pasta.
  - **Actuel:**
    - Modern Ripe bread restaurant, one of their selling points are the restaurant views and luminosity. They plate their dishes clean and elegant making the client feel the same way. There could be space for somethign fro growing vegetables or maybe something outside.

  - **Hos Henius :**
    - Traditional danish small restaurant, not modern, really small and with lilet space. They use lots of herbs and no so many greens.
  - **La locanda :**
    - Italian traditional restaurant, in summer and spring they have a big terrace, use lots of hervs, most of their costumers go there for the taste of the food
  -

- **Fast food chain**
  - **Sunset boulebard:**
    - Fastfood chain restaurant similar food to MC, clients go there for fast take away and convinience. There is space for our product but costumers don't

really apreciate or care about it. One of their restaurants in CPH has a vertical garden for herbs, but they use it more of a decorative element more than functional.

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

With this activity it has been possible to have an overview of the restaurant categories in Aalborg and we can see that fast food chain restaurants or chinese restaurant wont be the target of our prduct as most of this their selling point is their low prices and not the quality of the food .
The Luxury ones could be a good fitting restaurant category as it might attract more client by making also part of the experience and they will get fresher quality of produce. With the Eco and vegetarian would be also a great fit but it will have to requirer lots of space to be able for them to be 100% selfsufuciten, so maybe not have all the production in the dining area but maybe in a separate space like a depo roon or something like that.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

The ideal and perfect fit would be a restaurant that their main selling pont is the freshnes, self suficentcy and ecological aspect of the food. Their min decoration would be the vertical gardens.

Now from the exsinsting restaurants the category would be luxury and vegetarian, but it has been oboservd that the implementation best would be gradual as the restaurant don't have much initial space, so a gradual implementation can lead to and expansion of the restaurant depending on the costumers results.

For this gradual implementation the group suggests that they start first been 100% selfsuficient of on one category , the easiest would be microgreens and then proceed to the ampliation with the herbs and at last the leafy grens as this one requirer much more produce quantity and growing space. Haveving an incremental implementation also makes the initial investment much more affordable.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

https://restaurant-alimentum.dk/en/farm/
https://aktuelaalborg.dk/

Appendix 07 - Vegetable Research

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim with this worksheet is to research the types of vegetables that there are, the growing timeline and what conditions are necessary for them to grow. This activity will be done through desktop research and the information will be gathered in this worksheet so that it is possible to implement the necessary considerations in the design.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

Vegetable is a broad term used to describe the edible part of herbaceous plants. This can beetroot, stems, flowers, leafes, fruit or seeds. The vegetables are classified in many different ways, the most common classification is the following:

Leafy greens: These include greens such as kale, collard greens, spinach, and cabbage among many others. It is typically the edible leaves of the plants. These take approximately 3 weeks to be ready to harvest once seeded. [1]

Microgreens: These are the young seedlings of larger vegetables and herbs. These can be harvested only 7 to 14 days after being seeded. They include many different varieties in which the most common ones are watercress, radish, and mustard microgreens. [2]

Cruciferous: These include vegetables such as cabbage, broccoli, cauliflower, etc. These take between 100 and 150 days to be ready for harvesting.

Root: This group of vegetables includes potatoes, carrots, and onions among many others. In this case, the edible part of the plant is the root, as the name suggests. These usually take around 30 days until they are ready to harvest. However, some of them take up to 100 days.

Edible plant stem: These include vegetables such as asparagus, celery and rhubarb. As the name indicates, they are grown for their stems. Some of these stem vegetables like rhubarb, can take up to two years before they can be harvested. Others like the celery can take up to 140 days before they are ready.

Herbs: This group is further divided into two, fast growing and slow-growing herbs. The fast growing herbs such as dill, basil and cilantro are typically ready to harvest after two months. The slow-growing herbs like rosemary take around nine months if they haven’t gone bad before.

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

With this activity it is possible to find that there are different types of vegetables. This classification is one out of many possibilities but it is deemed good since it contains the vegetables that were seen in the shadowing from Appendix 01.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

This activity has given insight to how many days each group takes to grow. The next steps would be to find the ideal growth conditions. To do this, it is believed some groups of vegetables have to be chosen so that the group can focus on only some types. It currently seems unrealistic that restaurants would buy a product to help them grow greens that would be ready in 140 days to a year, therefore this are not taken into account.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

[1]https://agrotonomy.com/crop-yield-of-a-tower-farm/#:~:text=and%20other%20factors.-,In%20good%20growing%20conditions%2C%20lettuce%2C%20herbs%2C%20and%20leafy%20greens,21%2D28%20day%20growing%20cycle

[2] https://hydroponicway.com/how-to-grow-microgreens-hydroponically

[3]https://www.betterhealth.vic.gov.au/health/healthyliving/fruit-and-vegetables

[4]https://www.healthline.com/nutrition/leafy-green-vegetables

[5]https://extension.umd.edu/resource/growing-leafy-greens-home-garden

[6]https://integrisok.com/resources/on-your-health/2021/july/what-are-microgreens

[7]https://www.urbangardengal.com/growing-cruciferous-vegetables/#:~:text=Most%20vegetables%20in%20the%20cruciferous,days%20from%20germination%20to%20harvest

[8]https://www.southernliving.com/food/side-dishes/vegetables/what-are-root-vegetables

[9]https://www.grocery.coop/article/how-plant-root-crops#:~:text=Some%20root%20crops%2C%20such%20as,to%20anticipate%20when%20to%20harvest

[10]https://agritech.tnau.ac.in/horticulture/Ediple%20Plant%20Parts.pdf

[11]https://gardenerspath.com/plants/vegetables/propagate-rhubarb-seed/#:~:text=You'll%20be%20able%20to,are%2012%2D18%20inches%20long

[12]https://www.ufseeds.com/celery-seed-to-harvest.html#:~:text=Celery%20can%20take%20up%20to,a%20diameter%20of%203%20inches

[13]https://lettucegrowsomething.com/how-long-do-herbs-take-to-grow/#:~:text=TYPICAL%20TIMELINE%20FOR%20HERB%20GROWTH&text=Seeds%20for%20a%20hardy%20perennial,after%20they're%20transplanted%20outdoors

Appendix 08 - Feedback sketches 1 (Vertical garden)

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The objective of these interviews is to show two different chefs from different restaurants the first round of sketches to gain knowledge and insights. This is done in face to face interviews that are semi-structured. The sketches are shown and a small explanation is given so that they understand the idea of the concept. The feedback and insights are collected and the group also writes down their own feelings on the concepts so far.

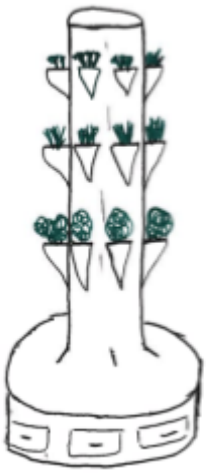
Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

The sketches are done in 3 different rounds. These rounds each have a theme to cover to target the different areas where it is assumed that space can be found to implement the solutions. Bullet points are made for the different sketches with the main feedback. Together with the chef's feedback, the team adds their own perspective on the different solutions taking into account some of the technical aspects of the project.

Outside in terrace

- **Common feedback:**
  - **Needs wheels if outside**
  - **No cables to trip over**

Leafy green tower

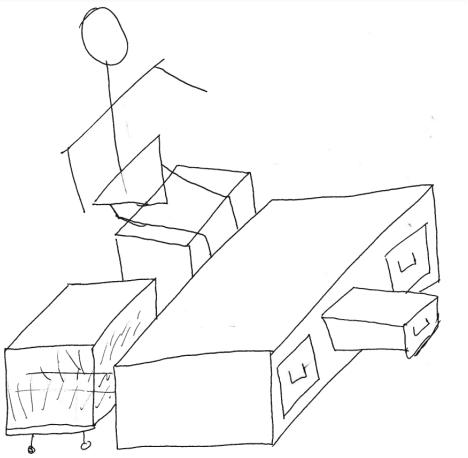


Chef’s feedback:

- They both like the concept, but agree that the application is limited as it needs to fit the ambient of the restaurant venue.
- As a display, it seems really visual and interactive without being directly in your face.
- It’s approachable.
- The main issue you have would be to dress the interior of the restaurant around it, it's hard to integrate it in an already existing one.
- It would need wheels so it can be put away or moved around the terrace.
- There should not be cables on the floor that the waiters can trip on.

Team’s feedback:

- The main issue seen is where to put the UV lights.
- Where to integrate the germination.
- Also might only be used for leafy greens and herbs.
- It looks really voluminous in comparison to how much greens it can grow
- Might seem too similar to other existing solutions for mass production.

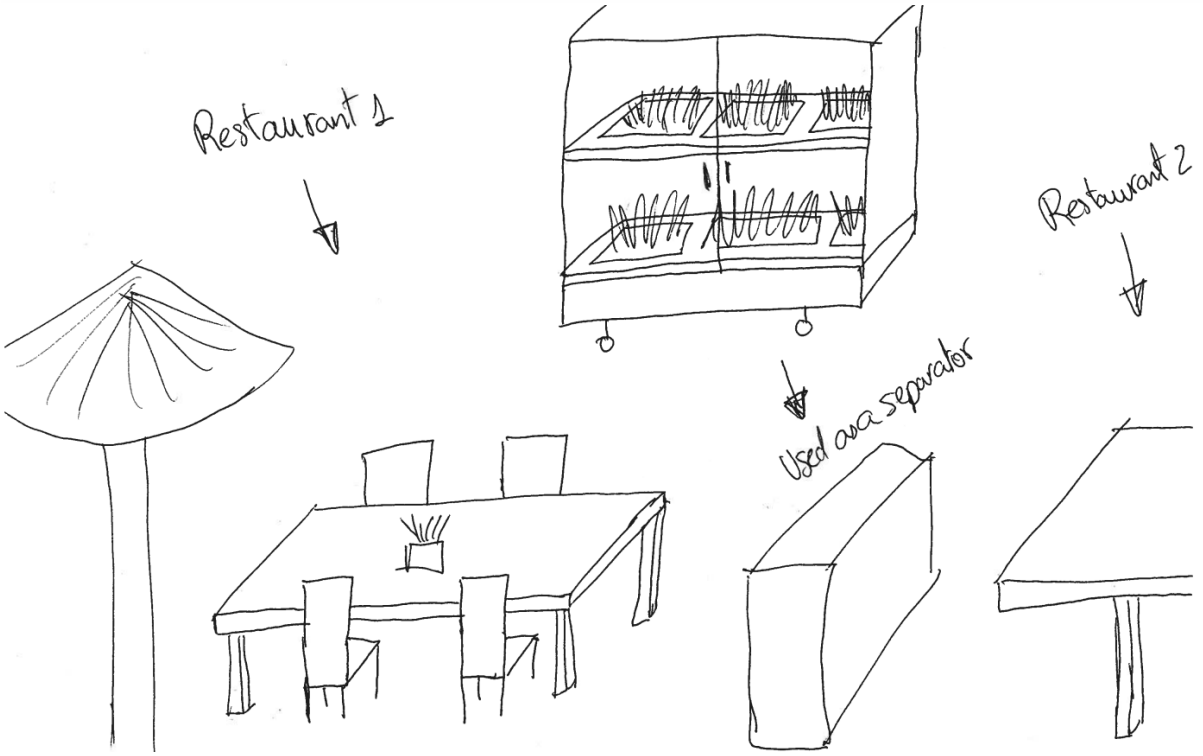


Chef’s feedback:

- It looks cool but she would feel weird sitting on top of plants
- She would not trust it and would feel uneasy, it needs to look sturdy, specially if it is see through.
- If a person sits on top of it they are kind of hidden, they don't shine.
- Not really sold on this one.

Team’s feedback:

- Does not look hygienic as it is close to the floor, people’s feet and people sitting on it.
- Might be inconvenient if the chef runs out of vegetables and has to go out to the terrace and ask the customer to stand up so they can get the vegetables.
- How to integrate lights, ventilation and water systems

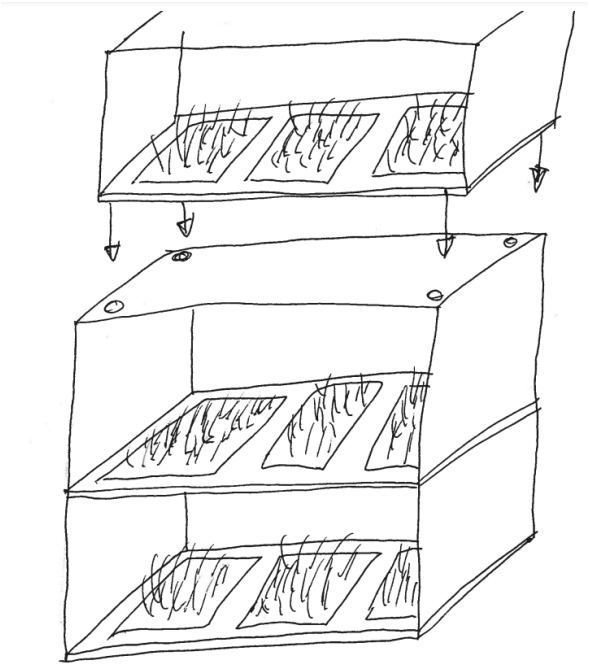


Chef's feedback:

- It's quite cool and you could have access from both sides,
- You can have customers on one side making it a more decorative piece and the other side for the staff , so it does not have to be decorative and can be more practical.
- Like that is movable and more versatile
- It can fit anywhere as it has a common shape unlike the column.
- It could be placed inside too if the weather is not good.

Team's feedback:

- Where can it be stored during the winter?
- Does it need to be stored or can it be hybrid?
- What if the restaurant does not have a terrace ?
- Is it too far to go get the vegetables outside?
- Do they need to put them out every day? It might not be very practical or convenient.
- Might require more work and time since they are several and not just one.



Chef's feedback:

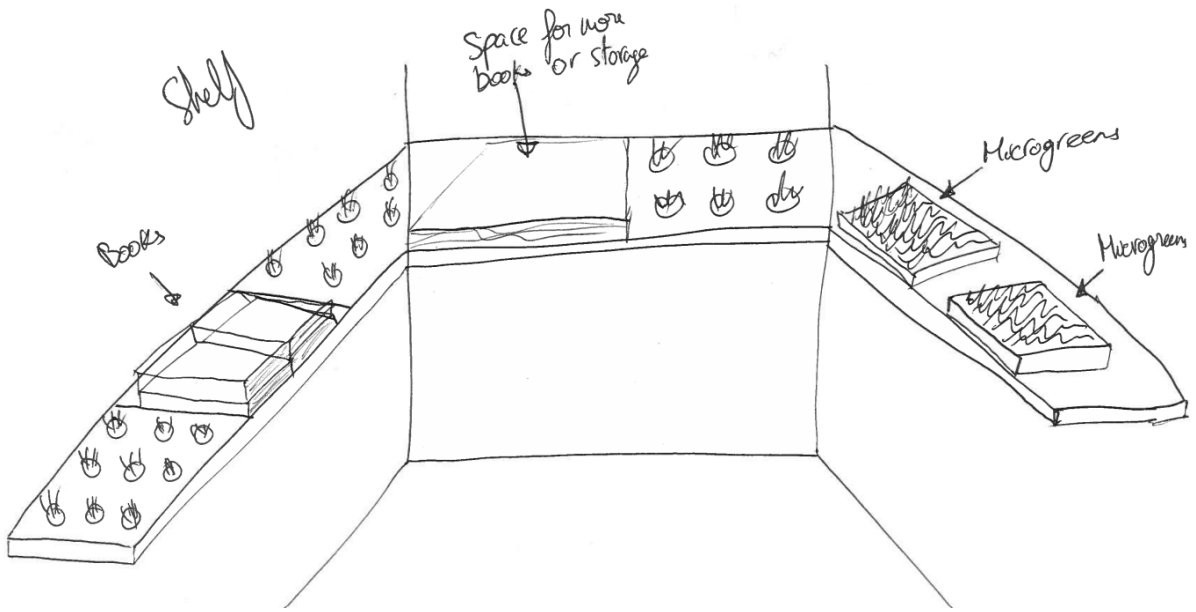
- The idea of being able to stack them is quite nice.
- The previous sketch could be done this way and it could be cool.

Team's feedback:

- Nice concept, might be too structural.
- Might be too much added work.

In the dining area:

- **It could look really attractive**
- **Would be nice to see the chef go out to harvest**

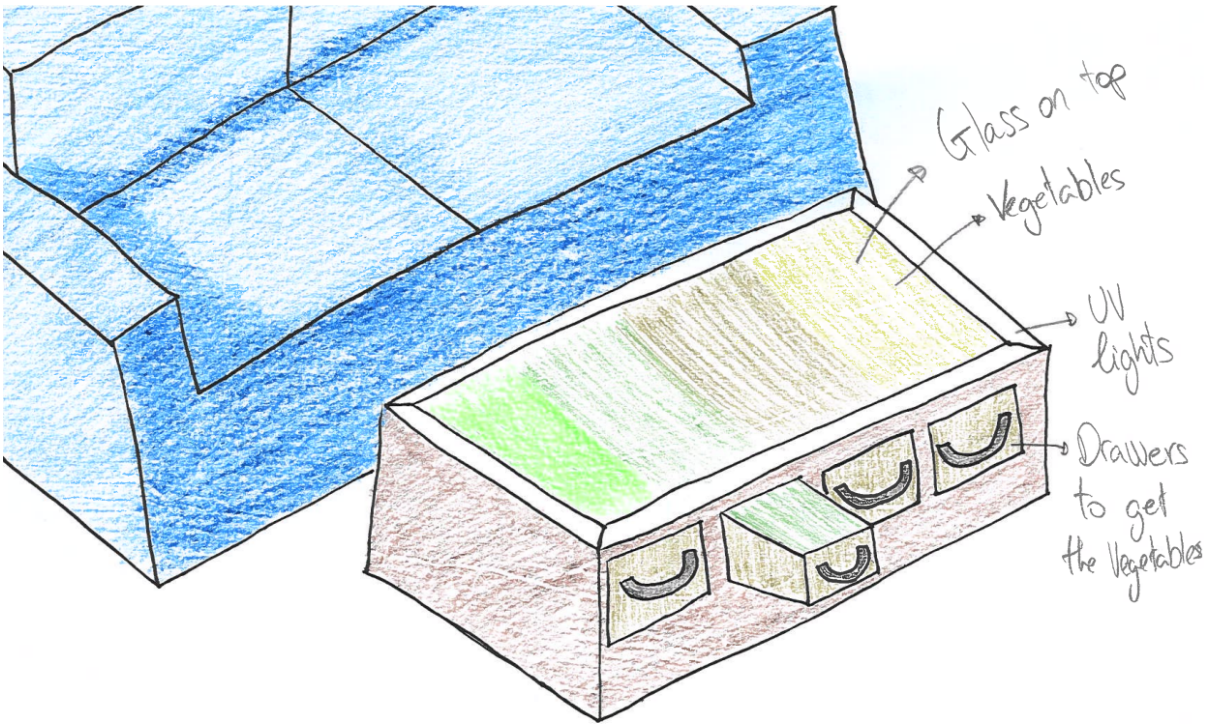


Chef's feedback:

- Seems too big and would take up a lot of space
- Not convinced unless it can be smaller, then it would have potential
- Visible and not in the way of the customers
- Does not take away any space on the floor

Team's feedback:

- How would it be hung on the wall?
- Would the restaurants have to replace stuff on the walls?
- If it is too high up the wall chefs can't easily reach the vegetables.
- Can it somehow be made more efficient and less space taking?

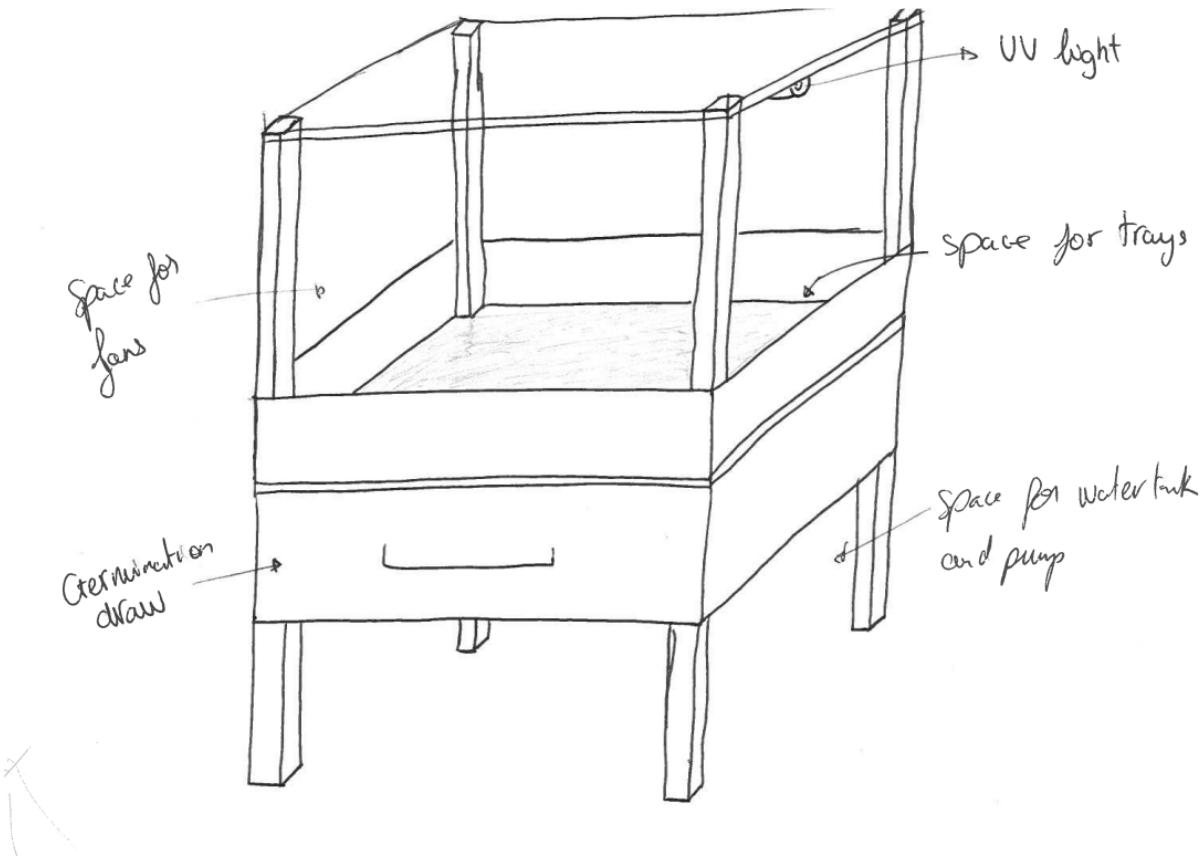


Chef's feedback:

- Hard to integrate.
- Same problem with the tower, and this one is really in your face.

Team's feedback:

- Does not fit in all restaurants.
- When the plants have been harvested it does not look very good.
- If they needed to harvest the customers would be disturbed.

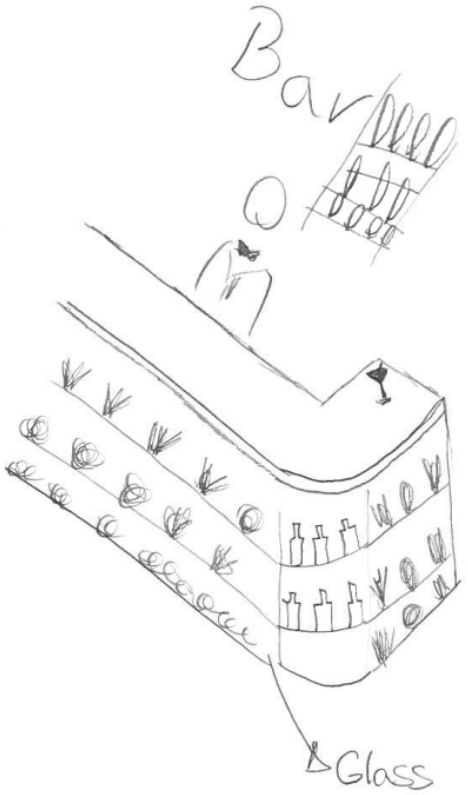


Chef's feedback:

- Like the concept.
- Simple.
- Looks like they could be stacked
- Likes that everything is integrated.
- But it looks quite structural and not like furniture to have in the restaurant.

Team's feedback:

- Might need many of these to be able to supply the minimum vegetable requirements.

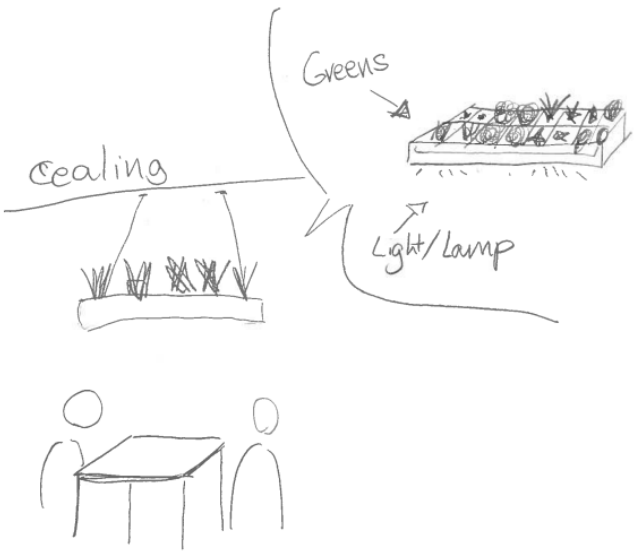


Chef's feedback:

- Great idea for a cocktail bar or a restaurant selling wines.
- It looks more decorative and there might not be sufficient space to grow everything.

Team's feedback:

- Needs an entire new bar structure
- It is a bit hard to access the plants closer to the floor when harvesting.
- Insufficient space to grow enough greens.
- Too narrow the market.

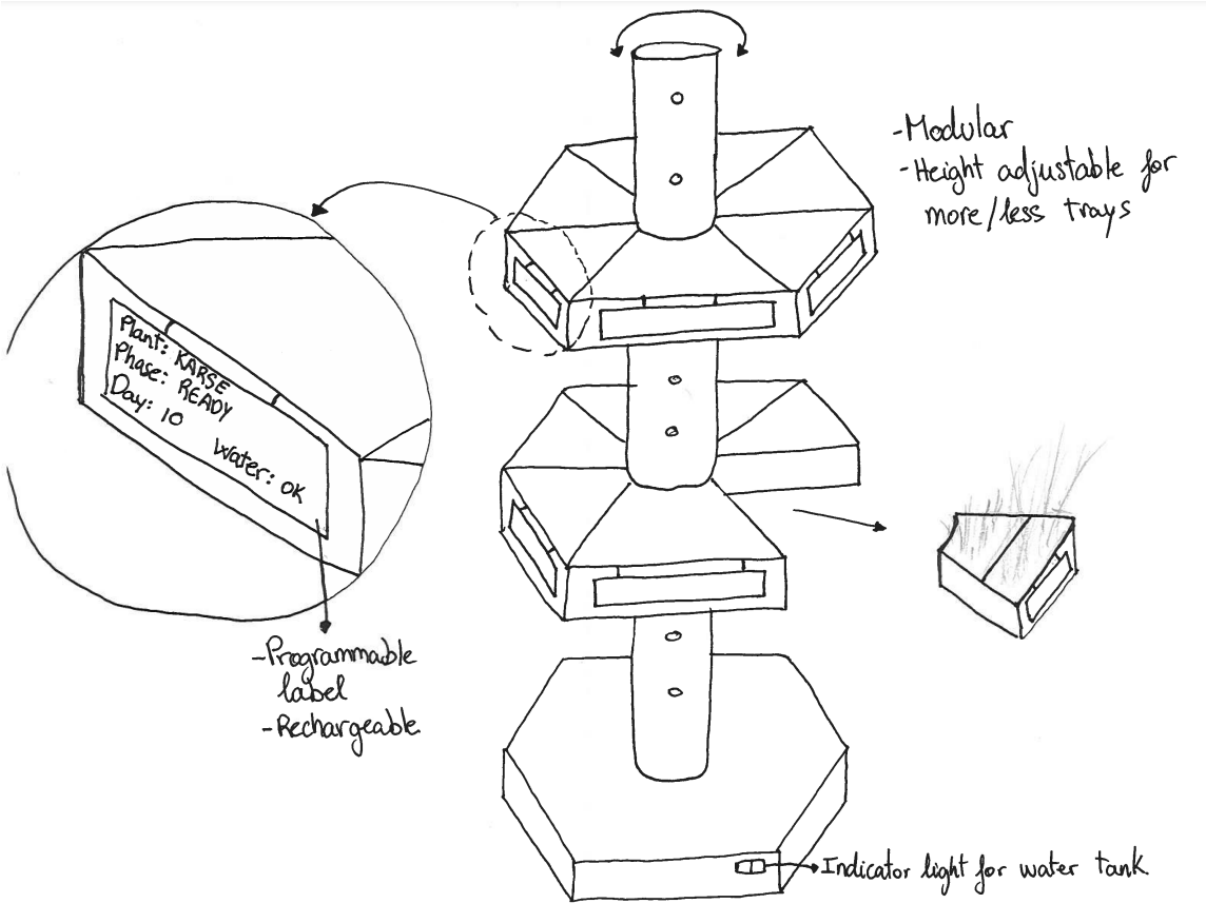


Chef's feedback:

- Could look nice and interesting, but again hard to integrate in to a restaurant
- Worried about having water on top of clients and lamps, not the best combination especially if the lamps are going to be lowered and raised.

Team's feedback:

- Takes more time as they are spread around the restaurant and not all in one place.
- This solution would be more expensive
- Worries: Spider webs, temperature, dust?



Chef's feedback:

- Like the height of the concept can be adjusted.
- Again it is really hard to implement and would have to decorate the restaurant around it.
- It is best to keep it in simple shapes.

Team's feedback:

- Too futuristic, it does not fit everywhere.
- It might seem the centre of attention.
- It's good that it's multiuser.

Inside the kitchen

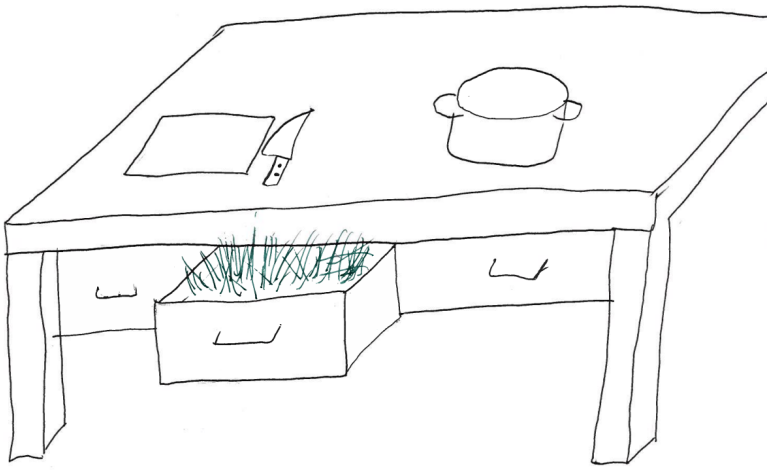
- **Take into account the fumes and possible toxic gases that are in the kitchen.**

Chef's feedback:

- Really like this one but she is not sure about the glass as it is in the kitchen,so maybe something else.
- She likes that it is all contained in one unit and the panels can be slid out to take out the greens.
- Main concern is the size and capacity, the yield is a big important factor as the rate in restaurants is quite fast.

Team's feedback:

- Takes too much space in the kitchen which there is much of.
- Is it space efficient enough?

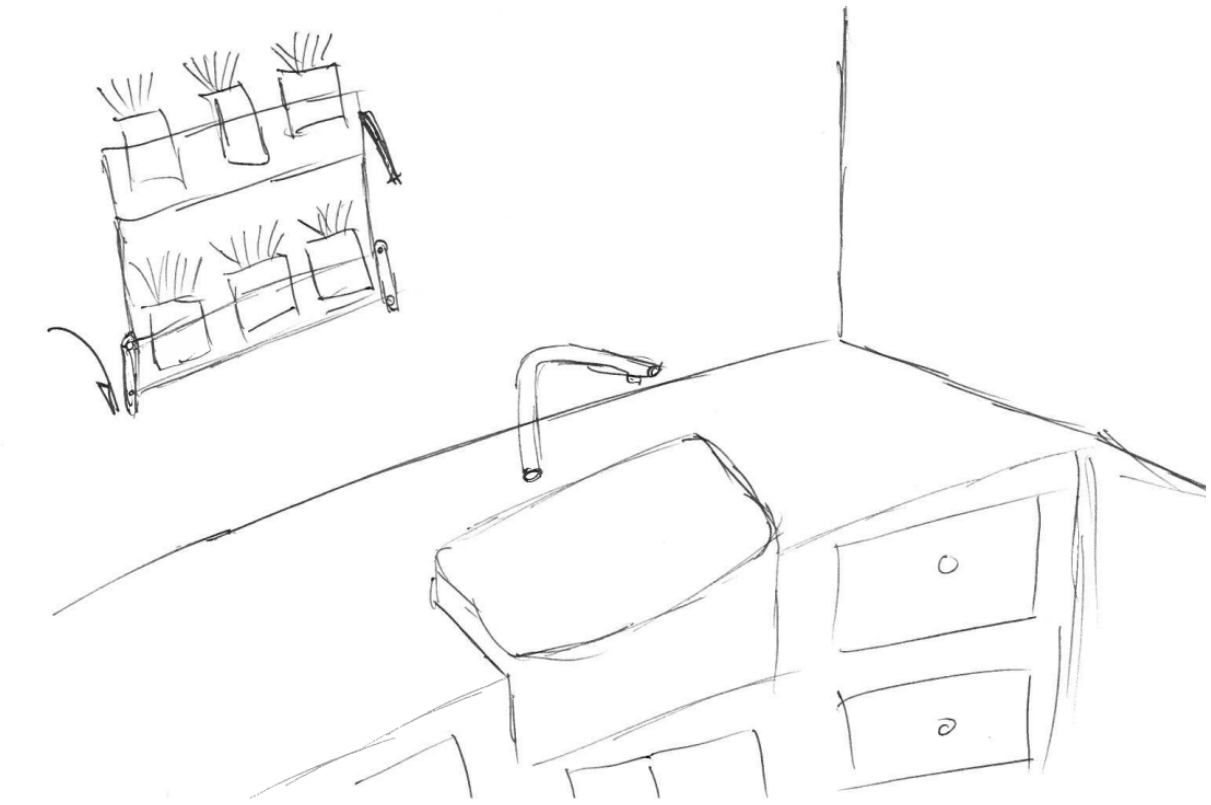


Chef’s feedback:

- Likes that it's in drawers.
- Seems practical.
- It needs to be kept hygienic and clean.
- Can be tricky as kitchens get quite dirty.
- Looks really accessible and handy.

Team’s feedback:

- Kitchen furniture needs to be replaced unless it can be made as an add on. Maybe not enough space to have it as an add on.
- Not enough space for herbs to grow
- Humidity could be an issue that leads to mould.



Chef's feedback:

- Like the idea as it comprises a few of the previous ideas, but not sure how it would work with the fact that comes in and out of the wall.
- It's easier to implement in a current kitchen but you might need to have several and there is not so much space for it.
- It looks different and nicer than some of the others.

Team's feedback:

- Is there a problem with the fumes? Heat?
- Is there enough space for several of these?

Evaluate

Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?

Thanks to this activity it is possible to see some common traits that the chefs like in some of the concepts.

Reflection

What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?

Appendix 09 - Growing medium

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to do some research as to what is the best method for indoor gardening. It is important to take into account that this vertical garden will be in restaurants and therefore there are some mediums, like soil, that are not suitable for this application.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

With the research done, it has been found that for restaurants and for the cleanliness that is required, the best option is to choose a growing medium that is mat-like for micogreens. With this it is meant that the growing medium will be like a sheet of material and not grains (like soil) that is to be used in the container. Furthermore for leafy greens, it has been found that the best option is to use a plug version of the medium.

Here there is a list of potential mediums with their advantages and disadvantages. The aim with this comparison is to pick a medium to use in the project.

Rockwool:

https://www.trees.com/gardening-and-landscaping/growing-media

Hemp mats:
https://typesofmicrogreens.com/best-growing-medium-for-microgreens/

Coconut coir mats:

https://everythinggreen.sg/products/coco-mats-for-microgreens#:~:text=Coco%20Mats%20are%20a%20great,the%20radicals%20to%20grow%20into.

cellulose mats:

https://www.turfquick.com/cellulose-fabric/

Hydroponic growing mats:

https://typesofmicrogreens.com/best-growing-medium-for-microgreens/

Biostrate:

https://na.quickplug.global/biostrate-home-grower/

With these advantages and disadvantages found directly from the different websites, it is now possible to rate the mediums. The rating will be done in according to the following criteria found from desktop research:

https://hydroponicway.com/is-a-growing-medium-necessary-for-hydroponics#:~:text=The%20most%20popular%20growing%20media,coir%2C%20made%20from%20coconut%20husks.

https://www.trees.com/gardening-and-landscaping/growing-media

-Good aeration and drainage
-Moisture retention
-Organic, biodegradable, environmentally friendly
-Sterile/ prevents pests and mold (aeration helps this process)
-Inexpensive and easy to obtain

What are the characteristics of ideal hydroponic growing Medium?

1. Good aeration and drainage
2. Good porosity
3. Low density
4. Non-toxic
5. Reusable/recyclable
6. Affordable
7. Flexible
8. Durable to withstand the test of time
9. Sterile
10. Chemical properties are neutrality (pH) and a good cation-exchange capacity.

What makes a great growing medium?

Eliminating all objective factors, an ideal medium is the one that

1. Is organic-made, biodegradable and environmentally friendly
2. Keeps an even ratio of air to water.
3. Has a medium cation-exchange capacity to hold nutrients.
4. Helps protect plants from pH changes over time.
5. Is inexpensive and easy to find
6. Is lightweight enough and easy to carry around

In this table it is assumed that the different options are all food safe as they are specifically used to grow microgreens and other herbs.

	Good aeration and drainage	Moisture retention	Organic, biodegradable, environmentally friendly	Sterile/ prevents pests and mold (aeration helps this process)	Inexpensive and easy to obtain
Rockwool	x	x			x
Hemp mats	x (not good drainage)	x	x		x
Cotton mats					x
Coconut coir mats	-x (not good drainage)	x	x		x
Hydroponic growing mats	x		x	x	
Cellulose mats					
Biostrate	x		x (only one of the options)	x	

From this table, it is possible to narrow down the options to only 3. Hemp mats, Coconut coir mats and Biostrate. The reason for choosing Biostrate over Rockwool is the environmentally friendly aspect.

Because the aim of this project is to avoid reduce waste and make the whole process of restaurants obtaining microgreens more sustainable (plastic waste, transport reduction…), it would be counterproductive to choose a medium that does not help achieve the goal of the project.

Evaluate

Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?

As mentioned, with this research, it is now possible to narrow down the options to only 3. Hemp mats, Coconut coir mats, and Biostrate. The idea would be to test all three options to find out which one suits the application best. Unfortunately, this is not possible. Biostrate is an expensive and difficult-to-obtain medium and therefore will also be disregarded as one of the available options.

Reflection

What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?

This activity wa successful to narrow down the possible options as growing mediums. To finalise which growing medium should be used, a sample of both will be bought and tested to see if there are any significant differences between them. Because neither of them are very effective at draining the water, it is important to choose a watering system that will minimise the risk of mould.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

Appendix 10 - Dimensioning

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to calculate how much space is needed to ensure that the restaurants can be self-sufficient in microgreens, leafy greens, and herbs. To do this, a combination of desktop research, information gathered from the shadowing, and tests will be used.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

From Appendix 05, it is possible to see that approximately 6.2Kg of microgreens are used a week:

Microgreens					kr 799
Karse	500	26,4	4	kr 106	
Aerte skuld	500	99,79	4	kr 399	
Affila	1000	132	2	kr 264	
China rose	100	15,18	2	kr 30	

The weight of these microgreens is an approximation since, in the weight, the growing medium is included as can be seen in the pictures:

The trays that the group use have a dimension of 20x15cm. To see how much weight there is in each tray, a batch of microgreens is grown for 10 days to then weigh it:

As seen in the picture, there are approximately 160g (karse) to 240g (yellow mustard)per tray depending on what is being grown. Assuming that they use approximately the same amount of microgreens a day and that the restaurant is open 5 days a week, this means that they need 1.2 kg of microgreens a day. This means that they would approximately use 6 trays a day which, since the microgreens are ready to harvest in 7-14 days according to Hydroponic Way[3], they would need between 48 and 60 trays to be self-sufficient (the group aims to allow them to grow them between 8 to 10 days).

For the leafy greens, it is possible to see from Appendix 05 that the restaurants use approximately 2.5kg of leafy green leaves and 12 leafy green heads a week. (The differentiation is made because when the spinach and mizuna arrive at the restaurant they are already cut whereas the lollo bionda, lollo rosa, and fricille still need to be cut).

Salad				kr 0	kr 388
Spinach	500	46,2	4	kr 185	
Mizuna	500	52,8	1	kr 53	
lollo bionda	1	12,54	4	kr 50	
lollo rosa	1	12,54	4	kr 50	
Frillice	1	12,54	4	kr 50	

To grow leafy greens, instead of using trays, small net cups are used [1]. For each leafy green unit, 1 cup is needed. According to SMGardener [2], it is possible to harvest 250g - 300g of spinach per cup, meaning that the group would need a total of 22 cups for a week's worth of leafy greens in the restaurant. Since the restaurant is open 5 days a week, they would need 5 cups a day (to be sure they have enough). According to Better Pets and Gardens [4], leafy greens need approximately 3 weeks to grow. This means that for the restaurant to be self-sufficient, it would need 105 cups.

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

Thanks to these calculations, an approximation of how many trays of each type of greens are needed can be found. To know the dimensions of the product, it is necessary to combine this information with dimensions of where there could potentially be space in a restaurant.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

To finalise the dimensioning of the product, it is necessary to go out and measure spaces available in restaurants.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

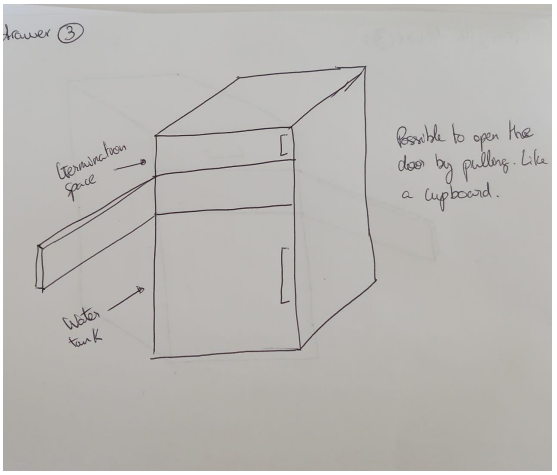
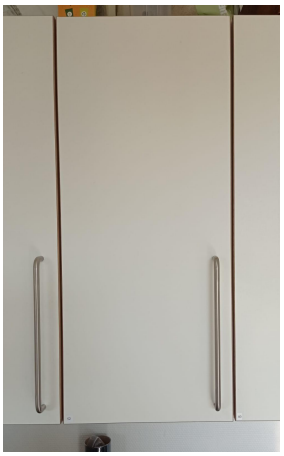
[1] https://www.citygreens.shop/categories/net-pots/700386000015518934 (28/04)
[2] https://smgardener.com/grow-hydroponic-spinach-in-nft-seed-to-harvest/ (28/04)
[3] https://hydroponicway.com/how-to-grow-microgreens-hydroponically (28/04)
[4] https://agrotonomy.com/crop-yield-of-a-tower-farm/#:~:text=and%20other%20factors.-,In%20good%20growing%20conditions%2C%20lettuce%2C%20herbs%2C%20and%20leafy%20greens,21%2D28%20day%20growing%20cycle. (28/04)
[5] https://gardenguide4all.com/how-to-grow-dill-hydroponically/#:~:text=Allow%20the%20seeds%20to%20germinate,as%20you%20would%20normally%20do. (29/04)

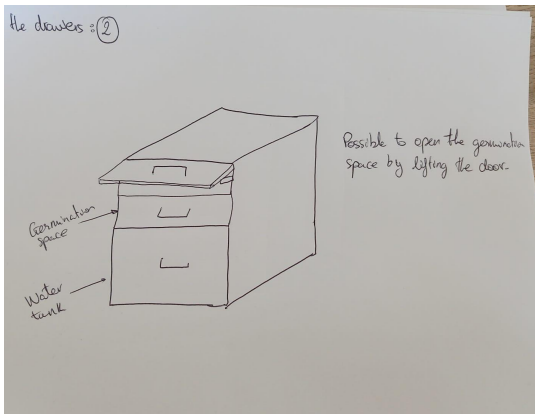
Appendix 11 - Explorative dive into the germination, storage, and water tank area

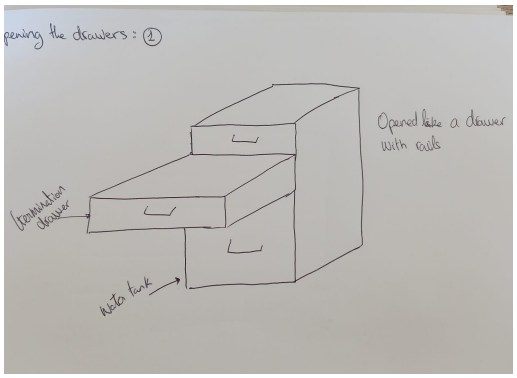
Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

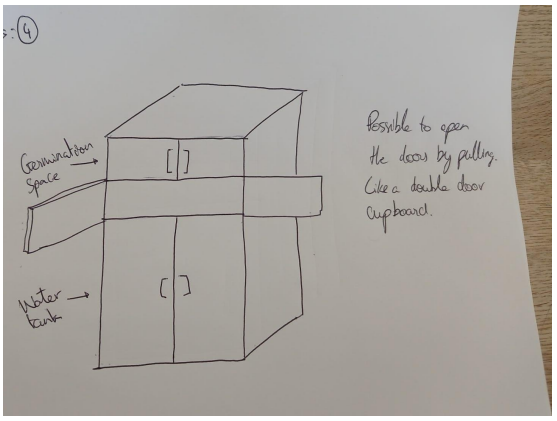
The aim of this worksheet is to develop the germination, storage, and water tank area of the concept. To do this, sketching rounds will be used and then the real-life mechanisms by which the sketches are inspired will be tested. Once they are done, a pros and cons list will be made to ease the comparison and decision-making to find the best solution.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

<table>
<tr><td>The sketch (1 door cupboard)
 
</td><td>The real-life mechanism
 
  </td></tr>
<tr><td>Pros</td><td>Cons</td></tr>
<tr><td>- Less material is used than in the drawer option
- Only needs two hinges and a door panel</td><td>- Requires a lot of space to open the long door (taking into account it is 80cm long)
- Not easy for the user to place or pick up the germination seeds at the back of the cupboard</td></tr>
</table>

The sketch (Lifting door cupboard)	The real-life mechanism
	 
Pros	**Cons**
- Uses less material than the drawer option - Unlike the 1-door cupboard, when lifting the door it does not take up a lot of space	- Not easy for the user to place or pick up the germination seeds at the back of the cupboard - When the lid is up, it is hard to see what's inside the cupboard

The sketch	The real-life mechanism
	 
Pros	**Cons**
- Easy to access the germinating seeds at the back of the drawer - Looks better than the rest of the options when being opened	- Probably cannot carry the weight of the water tank (needs more looking into) - Uses more material than the rest of the options

The sketch (2-door cupboard)	The real-life mechanism
	 
Pros	**Cons**
- Better use of space than the 1 door option	- Hard to reach the germination trays at the back

These sketches give an idea of the mechanism and overlook but because the “real-life” mechanisms are not to scale, it is hard it evaluate how much space the different options require for the doors to be opened.

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

These sketches, mock-ups, and real-life mechanisms can be used to choose what mechanism should be incorporated into the product. For the germination space, it is decided to choose the drawers. Reasons being that it makes it easier for the user to interact with the trays that would be at the back of the drawer. For the water tank, however, because the drawer would not be able to carry the necessary weight, it is decided to not use any door. This decision is based on the fact that without the doors, the CO2e emissions and price are reduced. Furthermore, it allows the user to see the water level of the tank without having to open the doors.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

Having chosen the door that should be used for the concept, it is still necessary to figure out how the users will fill up the water tank. The interaction of the user with the water tank will be explored in a separate worksheet.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

Appendix 12 - Developing the water tank

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to explore the interaction between the user and the water tank to see what the best way of filling it up is. This component is placed at the very bottom of the concept since it is the heaviest and will add to the stability of the product. To do this, sketching rounds and acting out will be used and analysed. Once it is done, a pros and cons list will be made to ease the comparison and decision-making to find the best solution.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

In order to ensure that the greens survive and prosper, they need to be watered every day. Because of this, it is necessary that the water tank always has water in it. Here, the interaction between the user and the water tank is explored so that the user can fill it up when necessary.

Four possible ways of filling up the water tank are looked at:

Water hose

Pros:	**Cons:**
- Simple method and not needed to move anything - The kitchen might already have a hose (used for cleaning the kitchen)	- If the kitchen doesn't have one, an adapter is needed so it can be used with the sink - Taking the hose out might make a mess with water on the dining floor - Might need to be very long - Separate place for storing

Water jug

Pros:	**Cons:**
- Simple - They already have some in the restaurant - Doesn't require much effort to be used	- Needs to be used more often because of the small quantities -

Water supply

Pros:	**Cons:**
- Does not require any interaction from the user since it can be controlled via	- Needs a water supply in the dining area which is not very common in

the app - Can be completely hidden if the water supply is close by	restaurants - If not controlled properly it could overfill the water tank

Taking the water tank out

Pros:	**Cons:**
- Can be filled up from the water tap if the tank fits in the sink - No extra equipment needed	- When the water tank has been filled, it will approximately weigh 40kg. This can lead to a back injury for the user - The tubes and cables going from the pump to the rest of the product need to be disconnected. Otherwise, the pump needs to be taken out - This could lead to leaks if not reconnected properly

Evaluating these ways of refiling the water tank, the water supply, and taking the water tank out of the concept were instantly disregarded. The chances of having a water supply in the dining area of the restaurant are extremely low and therefore not a possibility. Likewise, the possibility of having an interaction with the concept that could injure a user is unacceptable and for that reason also ruled out.

Both remaining options require an inlet through which the water can be poured into the water tank. In this case, it is believed that it is not possible to force the user to fill the tank up in a specific way, and therefore, to ease the process, the inlet for filling up the tank is explored.

Outside look

- **Access points**
  - **Side :** If is placed on the side is less visible but at the same time less accessible, and if the modules are placed next to each other, it will be un accessible.
  - **Front :** If the acces point is placed on the front side it will visible fron the restaurant costumers,this will imply to be something small and discrete

Arter the positioning of the opening was decided (Front), some parameters where set. It needed to be discrete, easy to open and it needed to be closed, so water would not evaporate. Due to this different water caps where tested out.

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

The water hose and the jug are the most duable options as it cant couse health issues and also does not add more visible pipes so no extra space is needed, with the option of the water jug it can also be made more sustainable if rain water is used, tho this will have to be filtered so no leaves or rocks get in to the water tank. As for the water cap the treath method is one of the most comun and ensured a more closed environment and easily closing as there is no need to apply any type of force.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

The sketches helped to have a visualize to explain the idea, but the acting out was the one the grave the group a full understanding of the problem.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

Appendix 13 - Water level feedback

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

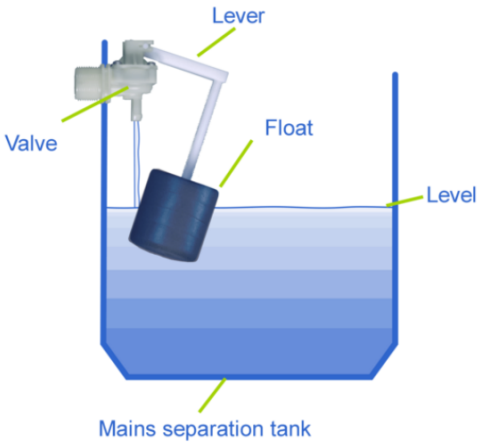
The aim of this worksheet is to explore and assess the different possibilities to prevent the water in the water tank from going under a certain level so that the water pump does not break. To do this, desktop research is made to see how different products currently communicate to the user the amount of liquid stored in a container.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

During the desktop research two main areas under which different ways of measuring how much liquid there was left in the tank were found:

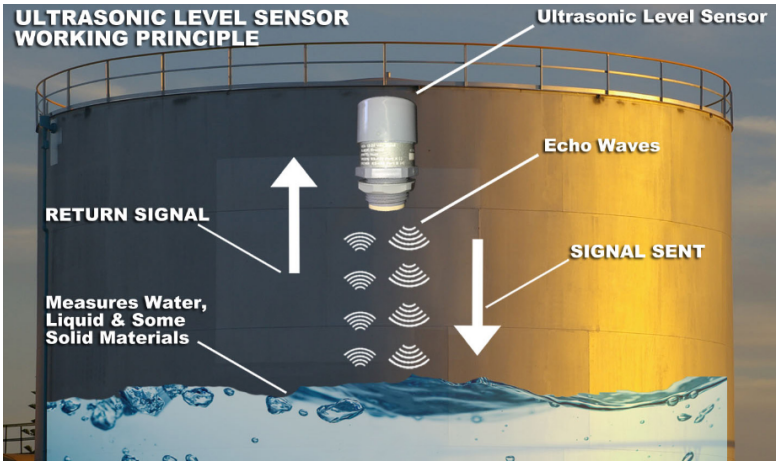
- **Mechanical**

The mechanical float valves are used in systems such as toilets where, when the water goes under a certain level, the valve is opened and allows water to fill the tank back up [1]. In this case, the exact amount of water left is not known, the float would simply trigger an event when under the level desired.

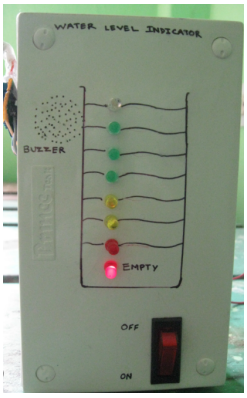


- **Electrical**

For the electrical water level sensors, there are many options available. Some of them require sending out some sort of signal (sound waves or light beams) that are then reflected back to the sensor and can be used to figure out the distance between the water and the sensor [2]. In this case, the water level can be known at all times.



Another example is a water switch that activates when in contact with water. These work almost like mechanical switches but are electrical. Again, it only to know the water at certain levels [3]



Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

Looking at these different possibilities, the ideal solution would be to have a sensor that would allow the user to see the water level all the time. The reason for this is that only having it visible at a certain time requires the user to immediately have to fill it up. If they forget it could lead to the water pump breaking.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

During one of the milestone meetings, a question was raised as to whether having these sensors was actually necessary or a feature creep. This made the group take a step back and look at the real need for these. Having these sensors has a lot of negative impacts on the product in comparison to the positives. It adds costs and CO2e emissions. These could potentially be removed by having the app send a notification every day/ two days to remind the users to take a look at the water level while having a transparent slot on the water tank where the water level can be seen:

[4]

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

[1] https://www.akmueller.de/en/float-valves (24/05/23)
[2]https://waterlevelcontrols.com/water-level-indicator/#:~:text=Water%20level%20indicators%20work%20by,to%20refill%20the%20water%20again. (24/05/23)
[3] https://www.instructables.com/Water-Level-Indicator-with-Alarm/ (24/05/23)
[4] https://www.tilina.lk/product/glass-bottle-with-water-level/ (24/05/23)

Appendix 14 - Material selection for frame

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to select what type of material the frame of the product should be made of. The aim is to keep the CO2e emissions at the lowest amount possible and the same goes for the price. In addition, the assembly of the product should also be taken into account trying to find a solution that will allow circular economy at the end of the product's life.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

To obtain the CO2e emissions for the materials, SimaPro is used. SimaPro gives CO2e emissions for the material before it is processed into the component that would be necessary for the product. Because of this, it is assumed that if a standardised component can be found for the product, it will be more CO2e-friendly and price optimised. To obtain information on the price and material properties, desktop research will be made.

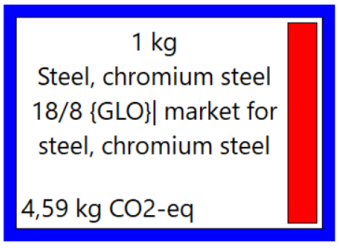
Aluminium extrusion:

Aluminum density is 2710 Kg per cubic meter[1].

Aluminium extrusion of the right dimensions manufactured in Poland costs 166.2dkk per meter[2].

Steel extrusion:

Stainless steel density is of 7500 Kg per cubic meter[3].



Stainless steel extrusion of the right dimensions manufactured in Germany costs 197.18dkk per meter[4].

How would the frames be put together?

When designing the product, the idea is to take the circular economy into account so that at the end of the product's life, the minimum amount of waste is generated.
Because of this, the idea would be to be able to reuse or repurpose the product. The first idea that comes to mind is that the product can be repurposed as a cupboard. Otherwise, it can simply be maintained and then reused in a different restaurant. In both cases, it is believed that it would be a good idea if the components were not permanently attached since it makes the process of maintaining the product more difficult if something breaks.

The aluminium extrusions have a t-slot system that allows nuts to be inserted in the extrusion and easily secure the two extrusions together. [5]

T-Nuts, slide-in

T-Nuts, push-in

T-Slot Strength

Information in regards to the maximum allowable t-slot load capability F. These values already include a safety factor (S > 2) against plastic deformation.

Profile type	Max. pull charge F
standard	5000 N
double br.	3250 N
semi	2500 N
light	2000 N
superlight	1750 N

The stainless steel extrusions on the other hand don't have this possibility meaning that a welded nut would have to be attached to the steel extrusion. Otherwise, the steel extrusions would have to be welded together or riveted together. [6]

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

Looking at the price and to way to connect the different extrusions, aluminium extrusions are the best options. This includes the thought process of including the circular economy and having the product not be permanently connected. However, when looking at the CO2e emissions, the aluminium extrusions are much worse.

One meter of aluminium extrusion weighs 1.46Kgs which means that per meter, there are 18.25 kg of CO2e emissions.
One meter of steel extrusion weighs 1.5Kgs which means that per meter, there are 6.89 kg of CO2e emissions.

The difference in CO2e emissions is almost a 1:3 ratio which is not good enough. The numbers obtained from SimaPro are for completely new materials. Since aluminium and steel are both recyclable, it is possible to drastically reduce the CO2 emissions for both of these materials. [7][8].

Alison Vernaillen, performed a study case to compare the CO2e emissions of a car body made from steel can compared it to one made from aluminium. Here she found that the aluminium body was 3 times more CO2e emittent than that of steel, this is the same ratio found earlier in this worksheet. Then, she performed the same calculations but with 100% recycled materials. Here she found that the CO2e emissions were basically the same for both materials. When 100% recycled, 1 kg of aluminium or 1 kg of steel emit only 2 kg of CO2e. [9]

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

With this worksheet, it is possible to see the importance of using recycled material to reduce the CO2e emissions. Aluminium, for example, is 6 times less CO2e emitting when 100% recycled. With this in mind, the ideal scenario would be to use 100% recycled aluminium extrusions so that price, CO2e emissions, and maintenance/non-permanent connection requirements are all satisfied in the best possible way.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

[1]https://www.thyssenkrupp-materials.co.uk/density-of-aluminium.html 18/05/23
[2]https://vslot-poland.com/en_US/p/Aluminum-profile-40x40-8-250mm-black/3295 18/05/23
[3]https://www.thyssenkrupp-materials.co.uk/density-of-stainless-steel 18/05/23
[4]https://auremo.dk/forside/2051-rustfrit-stal-firkantet-ror-14301-firkantet-ror-304-hule-sektion-s30400.html#/1238-laengde-1000mm/4112-storrelse-40x40x20mm 18/05/23
[5]https://www.rollco.dk/produkter/aluminiumssystem/system40-spor8/fasteners-connectors/t-nuts-ball-type-slide-in 18/05/23
[6]https://www.jhpfasteners.com/ 18/05/23
[7]https://international-aluminium.org/work_areas/recycling/#:~:text=Aluminium%20can%20be%20recycled%20over,is%20still%20in%20use%20today. 18/05/23
[8]https://www.steel.org/sustainability/#:~:text=Steel%20is%20100%20percent%20recyclable,same%20quality%20again%20and%20again. 18/05/23
[9]https://www.sustamize.com/blog/how-much-co2-is-saved-when-an-aluminum-automobile-frame-is-used-instead-of-a-steel-one 18/05/23

Appendix 15 - Material selection and feeling for doors and side panels

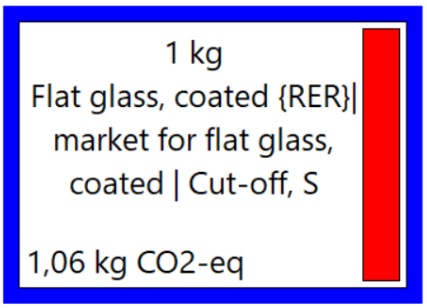
Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to select what type of material should the doors and the side panels be made in. Furthermore, the idea is to explore what type of feeling or expression the user should experience when opening the doors. To take this decision, many different parameters need to be taken into account. The parameters for choosing the material are price, CO2e emissions, safety, and material properties.

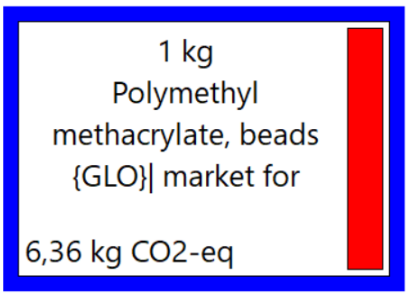
Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

To obtain the CO2e emissions for the different materials, SimaPro is used. Desktop research is used to find information on material properties, safety, and price.

Glass:
Standard windows are currently made out of float glass, but the group is worried about the impact resistance and how the product should communicate this. [1]
The price for a square meter of glass is 56.17 pounds which is roughly 481.64 dkk [2].

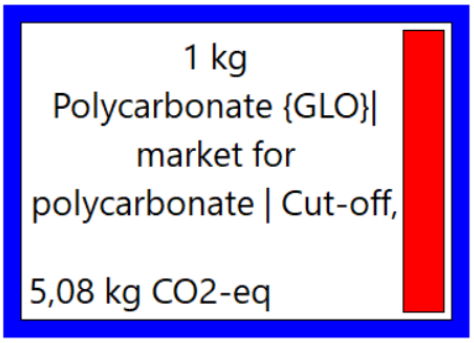


Plexiglass:
Normally used to replace glass because of its strength, impact resistance, and resistance to the elements [3].
The price for a square meter of plexiglass is 526dkk [4].



Transparent bio:
NAS / Luran, are two biopolymers options with very low CO2e emissions (it says up to 99% reduction in comparison to the same material without the bio part, NAS is a methyl methacrylate and Luran is an acrylonitrile copolymer). Their applications however are small household utensils so the application might not be suitable for the doors of the vertical farm. [5]

Polycarbonate:
The price for a square meter of polycarbonate is of approximately 627dkk [6]. Like the plexiglass, polycarbonate sheets have high impact resistance.



Summary: For now, it looks like the best solution price-wise and CO2 emissions-wise is the glass. When it comes to mechanical properties, glass might not be the best option as it will shatter if impacted with high strength in contrast with plexiglass or polycarbonate. However, glass is more scratch resistant in comparison with the other two options. For the NAS / Luran, the group is trying to contact the company and the manufacturer to see if the application would be suitable. For now, it has not been possible to contact them but the worksheet will be updated if it happens.

Feeling when interacting and visual expression:
The side panels have a full frame surrounding them which adds to the visual effect of them being strong, long-lasting, and quality. The doors however are moveable and need to be further analysed. Different options are thought of for the doors:

Visual expression:
Frameless:
Fragile looking in comparison to a door with a frame. Dangerous if it has sharp corners so they need to be rounded. Needs to be stiff and strong enough such that the doors can be open without the glass bending since it can lead to it breaking. No extra components are needed.

With frame:
Looks very sturdy in comparison to the door without a frame. Edges still need to be rounded since it can lead to injury for the user. In this case, the frame would be taking the bending moment so the frame would have to be strong enough. Adding a frame means adding more materials (probably aluminium) which increases price, assembly, and CO2e emissions

Feeling when interacting:

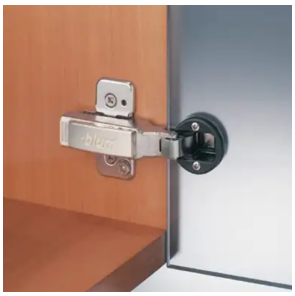
Magnetic:
A magnet could be used to ensure that the doors are going to remain closed throughout the day and will not easily open. Furthermore, when opening the doors it is necessary to overcome the magnetic pull which gives a feeling of quality.


[8]

“Rotary” hinge:
Having rotary hinges like the fridges in supermarkets. These hinges make the doors feel very loose and can accidentally be flung open.


[9]

“Spring” hinge:
The spring hinges ensure that the doors will both, remain closed when closed and remain fully open when open. This gives the user the safe feeling of the door not closing on them while they are taking out some of the greens. Furthermore, because of having to overcome a slight force both to close and to open the vertical garden, gives the feeling of security.


[10]

Suction/ magnets:
Like in fridges or freezers, gives the feeling of revealing something of high importance that has to be well sealed off.

 [11]

Summary:
With these different options in mind, it is necessary again to take into account that adding too many extra materials will increase price and CO2e emissions. No matter what, a hinge is needed for the doors. Having “rotary” hinges does not give a feeling of quality or security since the doors can be swung open and can keep closing on the user. The “spring” hinge on the other hand solves these issues and therefore is seen as the better solution for the user. At the same time, it is assumed that thanks to the safety that this hinge provides, the frame on the doors is not necessary (this decision is taken also taking into consideration the price and emissions that it would take).

Apart from the hinge, another important factor in the interaction is the door handle. To explore this, different handles are looked at:

 [12]	 [13]	 [14]	 [15]	 [16]
Handle where only the fingertips are to be used	Handle where the whole hand can be used	Handle where only the fingers are to be used	Handle with a different shape for only the fingers	Handle with different texture for only the fingers

Here, the group wants to transmit to the user the fragileness of the design and of the plants. Using a door handle that allows the user to pull with the whole hand does not transmit the same message. Because of this, the door handle that only allows to pull open with the fingertips is chosen since it will help the user to be gentle when opening the doors.

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

Thanks to this activity, the side panels and door materials, and design have been chosen. The material chosen is glass due to the low emissions and price (price and emissions calculations can be seen below). The doors will be frameless and a “spring” hinge will be used that holds the doors in a closed or open position. This gives the feeling of quality when opening the doors and security to the user when they are interacting with the greens since they don't have to constantly worry about the door closing on them.

	Total area needed in square meters	Total volume	Density	Price per square meter	CO2e emissions per kg
Glass panel	1,605456	0,00802728	2500	481,64	1,06
Plexiglass panel	1,605456	0,00802728	1190	526	6,36
Polycarbonate panel	1,605456	0,00802728	1200	627	5,08

Total price	Total CO2e emissions
773,25	21,27
844,47	60,75
1006,62	48,93

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

There is still concern about the glass door being stiff enough to overcome the “spring” hinge strength without shattering (or suffering a bending moment). Likewise, the group is still concerned with the glass shattering if accidentally hit with a tray or smth. A possible solution for this is changing to a stronger glass type, maybe toughened glass or even double-glazed toughened glass. This change in glass would also imply a change in CO2e emissions and a change in price.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

[1] (https://airmasterwindows.com/impact-resistant-windows-how-they-work-and-why-you-need-them/#:~:text=Standard%20glass%20windows%20typically%20are,glass%20plus%20(SGP)%20technology. 18/05/23

[2] https://www.norwich-glass.co.uk/product/5mm-clear-float-glass/ 18/05/23

[3] https://www.binswangerglass.com/blog/glass-or-plexiglass/#:~:text=Glass%20tends%20to%20cost%20less,elements%20and%20erosion%20than%20glass. 18/05/23

[4] https://interglas.dk/shop/akryl-klar-5-521p.html 28/05/23

[5] https://products.ultrapolymers.com/nas-eco-and-luran-eco/ (18/05/23)

[6] https://plastdirekt.dk/produkt/polykarbonat-2-till-10-mm-standardmatt/?gad=1&gclid=Cj0KCQjwmZejBhC_ARIsAGhCqnegVr83gQjut-_x_1pdFLvSpdde7ucaojOZSgZm7hks1buMebOeXWQaArrxEALw_wcB 18/05/23

[7] https://www.saint-gobain-glass.co.uk/en-gb/architects/physical-properties#:~:text=The%20density%20of%20glass%20is,or%202500%20kg%20per%20m3. 18/05/23
[8] https://www.pinterest.com/pin/322359285814615288/ 18/05/23
[9] https://melovesm.life/product_details/424438686.html 18/05/23
[10] https://www.wwhardware.com/blum-94-clip-top-glass-door-self-closing-hinges-b075t4 18/05/23
[11] https://speedyrefrigeratorservice.com/blog/how-to-keep-the-refrigerator-door-closed/ 18/05/23
[12] https://copenhagenhomedesign.dk/collections/all/products/nordhavn-cylinder-knop-i-mat-sort# 24/05/23
[13] https://copenhagenhomedesign.dk/products/skjern-knop-i-klassisk-design-i-mat-sort?_pos=5&_sid=7736ea9a0&_ss=r 24/05/23
[14] https://copenhagenhomedesign.dk/products/osterbro-mobelknop-i-sort-messing-med-diamond-cut?_pos=1&_sid=7736ea9a0&_ss=r 24/05/23
[15] https://copenhagenhomedesign.dk/products/kibaek-knop-i-sort-bakelit-med-traeskrue-i-elforzinket-stal?_pos=4&_sid=7736ea9a0&_ss=r 24/05/23
[16] https://copenhagenhomedesign.dk/products/vesterbro-mobelknop-i-massiv-messing-i-mat-sort?_pos=2&_sid=7736ea9a0&_ss=r 24/05/23

Appendix 16 - Tray designs

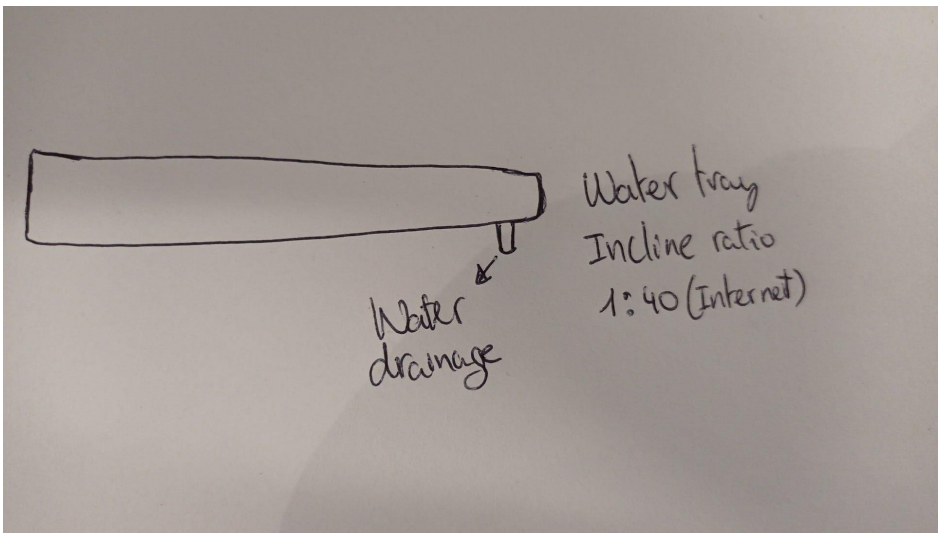
Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

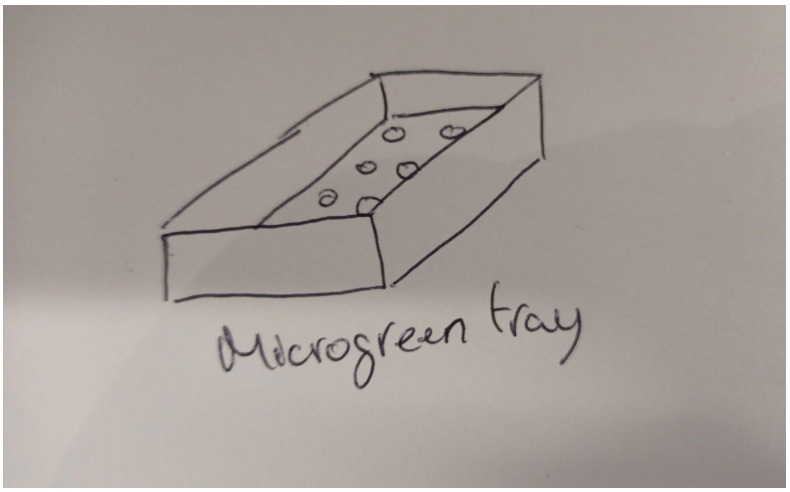
The aim of this worksheet is to design the four trays that are needed to grow greens. The design of these trays is interdependent and therefore is explored simultaneously. This was done via quick sketches and evaluating the pros and cons of each.

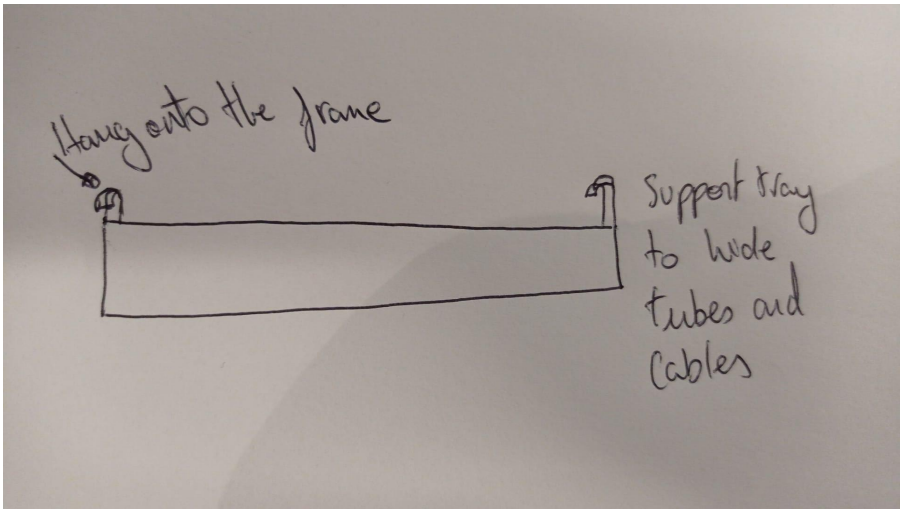
Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

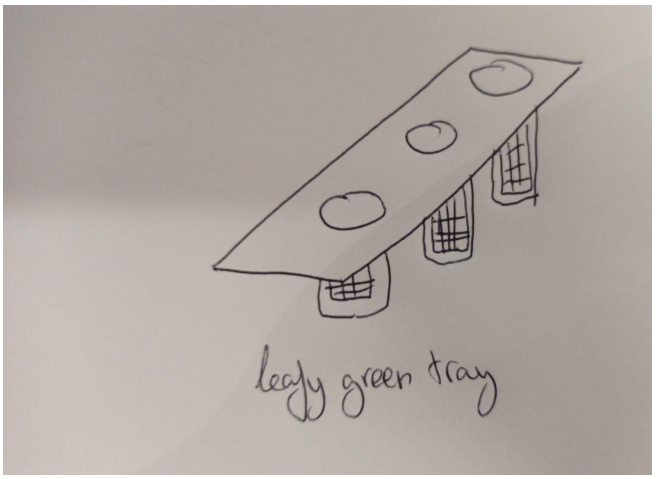
The trays being designed in the worksheet are the draining water tray, the supporting tray, the microgreens tray, and the leafy greens tray.

A first sketch is drawn up of each tray:

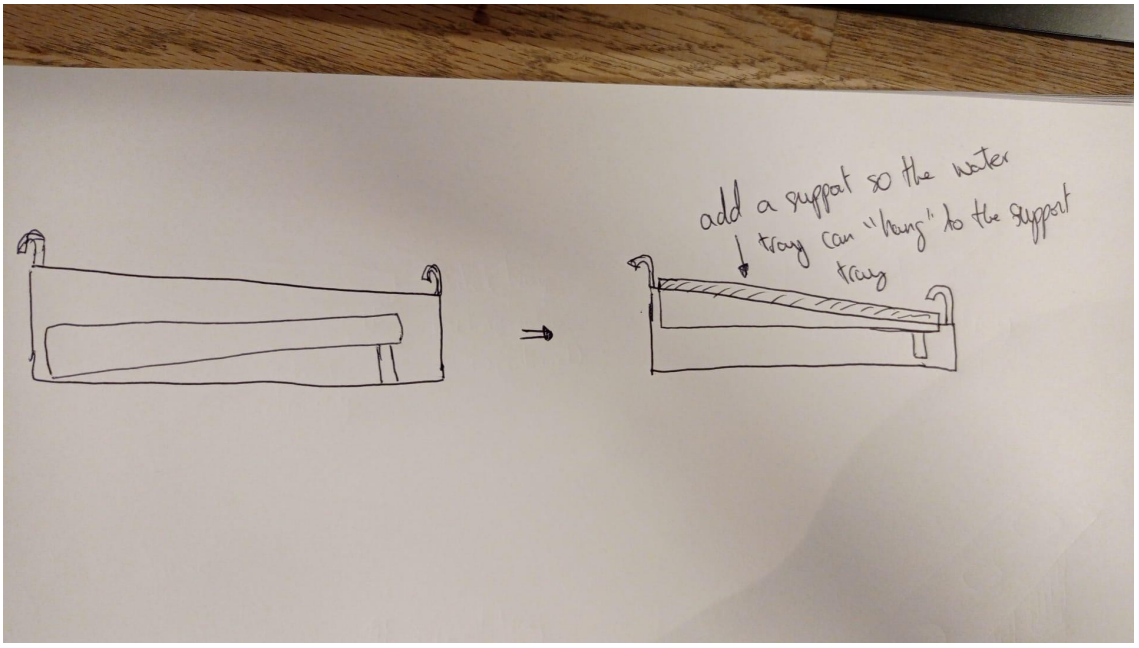








With these designs in mind, the next step is taken. This step consists of putting the draining tray on top of the support tray.



As can be seen on the left-hand side of the picture, the draining tray could easily just sit at the bottom of the support tray. In this case, the outlet of the tray would tilt it in the wrong direction completely negating the effect of the incline. Because of this, a support rim is added to the draining tray so it can sit on the edges of the support tray.

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

This activity gives way to seeing how the different trays should interact between each other and how the user should interact with them. It is decided to choose, what is assumed to be, the cheapest and least CO2e emittent option since it uses less material.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

It is unknown if the support tray will hold and therefore needs to be explored further. Next step is to research what type of material should be used for it.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

Appendix 17 - Material selection for the custom parts

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to select what type of material the plastic parts of the product should be made of. The aim is to keep the CO2e emissions at the lowest amount possible and the same goes for the price. In this case, because the components are not standard, the manufacturing process of the component is to be explored.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

There are seven components that are being taken into account for the research:

- Microgreen trays
- Leafy green trays
- Draining tray
- The supporting tray
- Water tank
- Water tank lid
- Water tank inlet lid

The idea is that the users are constantly interacting with the microgreen trays and leafy green trays. The requirements for these are that they are food safe and that they are dishwasher-safe. Because of the quantity needed and the shape, the first idea that comes to mind is to manufacture them in plastic, some sort of injection moulding, or thermoforming.

During desktop research to figure out what type of plastic would be possible to use for the product, the group stumbled upon two companies that use bioplastics for their products.

- FKUR has a bioplastic called Terralene. This plastic meets all the needed requirements but it is only possible to injection mould it or extrude it [1]. This one is 100% recyclable and made from renewable raw materials. According to Productive parts, INC., standard machines for injection moulding can only handle dimensions of up to 10x10cm and if any bigger parts are needed, the expenses increase drastically [2].

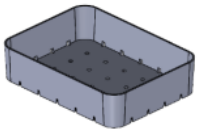
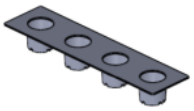
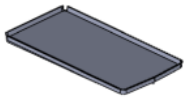
- FKUR also has Eastlon. This one is also a bio-plastic but it is only made from 30% renewable material. It is however still 100% recyclable [3]. This material has the same properties as PET plastic and therefore can not be washed in the dishwasher[4].

- Moldblade is a company that manufactures plastic parts in a sustainable way. They use green energy and also use bioplastics [5].

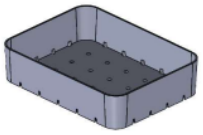
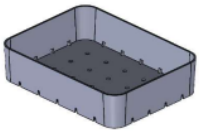
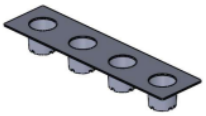
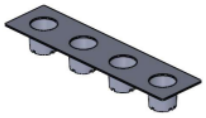
Both companies were contacted by the group. The cost of FKUR's Terralene is of 4 euros per kg whereas their Eastlon is only 2 euros per kg. Moldblade also asked for an email and took some time

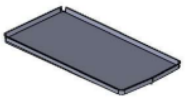
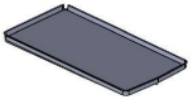
to come back with an answer. At the time, only three components of the product were ready so it's the ones the group got an answer for. This company is based in Spain so their estimate is also in Spanish and can be seen below.

Price for moulds:

ITEM	NOMBRE	IMAGEN	MATERIAL	CAVIDADES	SISTEMA INYECCIÓN	MATERIAL MOLDE					ACABADO SUPERFICIAL	TIEMPO PRODUCCIÓN (semanas)	Coste (€)	
						Plato A	Plato B	Cavidad	Punzón	Elevadores / correderas			Molde	Notas
1	**Microgreen tray (200 * 150 * 50 mm)**		PP reciclado	**1**	**Colada fría**	2738	2738	2738	2738	2738	**Pulido industrial**	12	**18.500 €**	
2	**Leafygreen tray (400 * 100 * 53 mm)**		PP reciclado	**1**	**Colada fría**	2738	2738	2738	2738	2738	**Pulido industrial**	12	**19.000 €**	
3	**Draining tray (412 * 811 * 41 mm)**		PP reciclado	**1**	**Colada fría**	2738	2738	2738	2738	2738	**Pulido industrial**	12	**69.000 €**	
	TOTAL												**106.500 €**	

Price per unit depending on how many are produced:

ITEM	ARTICULO	IMAGEN	MATERIAL	PESO (g)	COLOR	LOTE	TIEMPO DE PRODUCCIÓN (semanas)	PRECIO UNITARIO (€)
1a	**Microgreen tray (200 * 150 * 50 mm)**		PP reciclado	115 aprox	Negro	1400	2	0,94 €
1b	**Microgreen tray (200 * 150 * 50 mm)**		PP reciclado	115 aprox	Negro	4200	2	0,82 €
2a	**Leafygreen tray (400 * 100 * 53 mm)**		PP reciclado	155 aprox	Negro	120	2	1,94 €
2b	**Leafygreen tray (400 * 100 * 53 mm)**		PP reciclado	155 aprox	Negro	360	2	1,63 €

3a	**Draining tray (412 * 811 * 41 mm)**		PP reciclado	789 aprox	Negro	560	2	6,04 €
3b	**Draining tray (412 * 811 * 41 mm)**		PP reciclado	789 aprox	Negro	1680	2	5,41 €

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

Moldblade's price estimate is based on them injection moulding the parts. As discussed with the findings during the desktop research, if the parts are over 10x10cm, the mould price increases drastically. Looking at the prices obtained from Moldblade, since the draining tray, in the worst-case scenario, would only be manufactured approximately 160 times, the costs of the mould would be too high per part (this means that per draining tray, the mold costs 431 euros or 3200dkk).

Because of this, it is decided that the production method for the plastic components should be thermoforming. This decision also makes more sense since, even in the long run, not enough plastic parts of each component would be manufactured to become mass production.

The material that should be used is the Terralene from FKUR since the group was told on the phone that these could be turned into the sheets needed for thermoforming. Ideally, the group would also like to use Terralene plastic for the production of other plastic parts (like glass protectors, water tanks, or water tubes) since these can be manufactured in the required processes by the Terralene and the machines and molds used can be the same as for the standardised parts. The group assumes it would be possible to simply buy the plastic ganulates and hand them over to the manufacturers. They would simply add those to the machine and the group would obtain the desired components.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

There is concern in the group as to what would be the price if Terralene was to be bought and handed to manufacturers so that they could produce the component needed. There is also a concern about the price of manufacturing the parts since making such big moulds (for the draining tray) is expensive and only 4 trays are needed per unit.

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

[1]https://fkur.com/en/bioplastics/terralene/ 19/05/23
[2]https://www.productiveplastics.com/part-size-is-a-big-factor-on-injection-molding-vs-plastic-thermoforming-productive-plastics/#:~:text=In%20fact%2C%20most%20standard%20injection,is%20also%20drastically%20more%20expensive. 19/05/23
[3]https://fkur.com/en/bioplastics/eastlon/ 19/05/23
[4]https://blog.monouso-direct.com/find-out-which-types-of-plastic-dishes-are-dishwasher-safe/#:~:text=Polyethylene%20Terephthalate%20(PET),-PET%20is%20a&text=It%20has%20a%20low%20glass,it%20will%20lose%20its%20shape. 19/05/23
[5]https://moldblade.com/empresa/ecofabricacion/ 19/05/23

Appendix 18 - CO2e emissions calculations

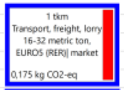
In this document the CO2e emissions are calculated.
The emissions are obtained from the SimaPro software when possible, otherwise a link will be added if found elsewhere.
Like during the calculations for the plastic packaging for the restaurant waste, the countries are treated as dots, meaning that if a product is bought in Denmark, the transportation km is 0
If more than one product comes from the same origin transport only counted once
To simplify calculations, only the components that make sense will be analysed. Small components like the bolts are deemed negligable next to the CO2e of the glass for example
Standard components that are bought like arduino and hinges, consist of many smaller different components. Here they are ignored because finding origin weight and necessary information is unrealistic
Because no numbers for CO2e have been found for Bioplastics, the number for the CO2e emissions of Polypropylane (PP) have been used since they have very similar mechanical properties. It is believed though that bioplastics have a smaller carbon footprint

CO2e emissions for the material of the available components

Component:	Volume (found from SolidWorks) SI units:	Density (found from desktop research SI units:	Reference	Amount	Total weight SI units	Emissions per kg (f	Reference if not from Sima Pro	Total emissions for material
Glass - side panels	0,0022	2500	https://www.saint-gobain-glass.c	2	11	1,06		11,66
Glass - doors	0,0019	2500	https://www.saint-gobain-glass.c	2	9,5	1,06		10,07
Aluminium frame	Total of 11,92m	1,56kg/m	https://www.rollco.dk/produkter/a	1	18,5952	2	https://www.sustamize.com/blog/how-much-cc	37,1904
Wood - Top panel	0,0027	500	https://keflico.com/produkter/okc	1	1,35	0,61	https://www.openco2.net/en/emission-factors/	0,8235
Wood - Fake back panel	0,0064	500	https://keflico.com/produkter/okc	1	3,2	0,61	https://www.openco2.net/en/emission-factors/	1,952
Wood - Side panel	0,0005	500	https://keflico.com/produkter/okc	2	0,5	0,61	https://www.openco2.net/en/emission-factors/	0,305
Wood - Back panel	0,007	500	https://keflico.com/produkter/okc	1	3,5	0,61	https://www.openco2.net/en/emission-factors/	2,135
Wood - Bottom panel	0,0007	500	https://keflico.com/produkter/okc	1	0,35	0,61	https://www.openco2.net/en/emission-factors/	0,2135
Wood - Drawer front	0,0009	500	https://keflico.com/produkter/okc	3	1,35	0,61	https://www.openco2.net/en/emission-factors/	0,8235
Wood - Drawer back	0,0007	500	https://keflico.com/produkter/okc	3	1,05	0,61	https://www.openco2.net/en/emission-factors/	0,6405
Wood - Drawer sides	0,0004	500	https://keflico.com/produkter/okc	6	1,2	0,61	https://www.openco2.net/en/emission-factors/	0,732
Wood - Drawer bottom	0,0012	500	https://keflico.com/produkter/okc	3	1,8	0,61	https://www.openco2.net/en/emission-factors/	1,098
Bioplastic - Leafy green tray	0,00015	935	https://iopscience.iop.org/article/	28	3,927	5,98		23,48346
Bioplastic - Microgreen tray	0,00012	935	https://iopscience.iop.org/article/	70	7,854	5,98		46,96692
Bioplastic - Draining tray	0,0024	935	https://iopscience.iop.org/article/	4	8,976	5,98		53,67648
Bioplastic - Support tray	0,0009	935	https://iopscience.iop.org/article/	4	3,366	5,98		20,12868
Bioplastic - Germination tray	0,0007	935	https://iopscience.iop.org/article/	2	1,309	5,98		7,82782
Bioplastic - Water tank	0,0018	935	https://iopscience.iop.org/article/	1	1,683	5,98		10,06434
Bioplastic - Water tank lid	0,00062	935	https://iopscience.iop.org/article/	1	0,5797	5,98		3,466606
Bioplastic - Inlet lid	0,0001	935	https://iopscience.iop.org/article/	1	0,0935	5,98		0,55913
Stainless Steel - Germination weig	0,0000532	7750	https://www.thyssenkrupp-mater	20	8,246	2	https://www.sustamize.com/blog/how-much-cc	16,492

CO2e calculations for the transport of the available material (only from outsid

Component	Origin	Destination	Distance (tkm)	Reference	CO2e emissions per t	Total emissions
Glass	England	Denmark	1,54	https://www.fluentca	0,00959	0,0147686
Wood	France	Denmark	1,607	https://www.osacarc	0,175	0,281225
Bioplastic	Brazil	Denmark	13,99196	https://www.searate	0,00959	0,1341828964
U plastic (to protect the glass)	England	Denmark	1,54	https://www.fluentca	0,00959	0,0147686
H plastic (to protect the glass)	England	Denmark	1,54	https://www.fluentca	0,00959	0,0147686
Aluminium (extrusions)	Sweeden	Denmark	0,89	https://www.osacarc	0,175	0,15575
Lights	China	Germany	18,664	https://www.fluentca	0,00959	0,17898776
Lights	Germany	Denmark	0,691	https://www.osacarc	0,175	0,120925
Fans	China	Germany	18,664	https://www.fluentca	0,00959	0,17898776
Fans	Germany	Denmark	0,691	https://www.osacarc	0,175	0,120925
Pump	China	Germany	18,664	https://www.fluentca	0,00959	0,17898776
Pump	Germany	Denmark	0,691	https://www.osacarc	0,175	0,120925
Steel and Aluminium plates	England	Denmark	1,54	https://www.fluentca	0,00959	0,0147686
Drawer rails	Poland	Denmark	1,049	https://www.osacarc	0,175	0,183575



For the Leafy greens unit, the CO2e emissions are:	205,0554616

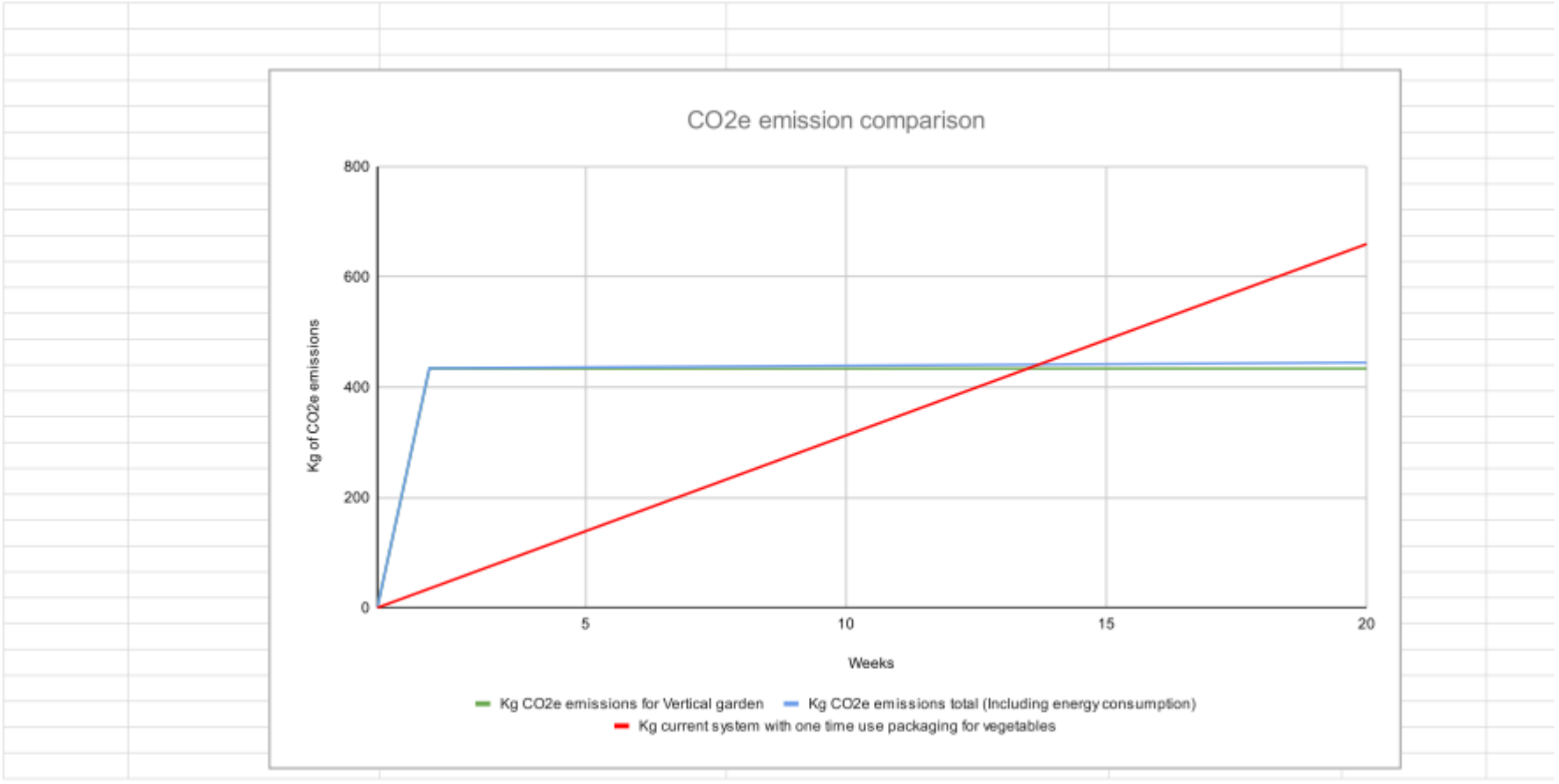
For the microgreens unit, the CO2e emissions are:		228,5389216			
				These calculated CO2e emissions are fixed per restaurant.	
Total CO2e emissions for 1 restaurant		433,5943832		On top of this, the CO2e emissions for the electricity to run this is necessary	

CO2e emissions a day to run these machines.					
Component	**Watts**	**kWh (multiply by hours used and divide by 1000)**			https://www.rapidtables
Pump	5	0,005		// used for a total of 1 hour a day	
Lights	12	0,168		// used for a total of 14 hour a day	
Fan	5	0,035		// used for a total of 7 hour a day	
Arduino (12V*0.2A)(worst case sce	2,4	0,0576		// used for a total of 24 hour a day	
		Total kWh a day:	**0,2656**		
		In CO2e emisisons:	**41,168**	g CO2e a day	https://www.statista.cor

From the previous Apprendix - "CO2e emissions from the different countries", it was found that:		
CO2e emissions plastic packaging:	2,31	kg CO2e (Assumed to be approximate for a daily basis)
Co2e emissions transport:	18,54	kg CO2e (Assumed to be approximately on a weekly basis)

Using the information above, a comparison table is made to see when the CO2e emissions for the vertical garden would break even
The calculations are made for a 5 month period

Weeks	CO2e emissions for the vertical garden	CO2e emissions power consumption	CO2e emissions current system
0	0	0	0
1	433,59	434,17	34,707
2	433,59	434,74	69,414
3	433,59	435,32	104,121
4	433,59	435,90	138,828
5	433,59	436,47	173,535
6	433,59	437,05	208,242
7	433,59	437,62	242,949
8	433,59	438,20	277,656
9	433,59	438,78	312,363
10	433,59	439,35	347,07
11	433,59	439,93	381,777
12	433,59	440,51	416,484
13	433,59	441,08	451,191
14	433,59	441,66	485,898
15	433,59	442,24	520,605
16	433,59	442,81	555,312
17	433,59	443,39	590,019
18	433,59	443,96	624,726
19	433,59	444,54	659,433
20	433,59	445,12	694,14
		12,70383147	
		12,70383147	440,9118787
			12,70383147 0
	(INTERCEPT(y2,x2)		800


CO2e emission comparison
800
600
400
200
0
Kg of CO2e emissions
5
10
15
20
Weeks
Kg CO2e emissions for Vertical garden
Kg CO2e emissions total (Including energy consumption)
Kg current system with one time use packaging for vegetables

Appendix 19 - Business model

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this worksheet is to make the business model for the product. To do this business model, the Business model canvas is used following the steps from Creately [1]. Here the different components of the business plan are explained.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

The business model canvas is used to explain in a simple manner how the business is going to make money. It allows a visual representation of the nine fundamental components of the business. [1] Bellow, the 9 components of the business model canvas will be shown and explained. Finally, once this is done, the visual representation will be given where the proposition for the business plan can be clearly seen.

1. Customer segment

This component of the business model canvas is where the target group for the product is found. Knowing the customer allows the product to be tailored to their needs. [1] In this case, the business is B2B where the customers are the restaurants that will be using the vertical garden. The idea is to target restaurants that are in between the fine dining market and the casual dining. This is because fine-dining restaurants have limited space for a product like this one and casual-dining restaurants require more units to be self-sufficient. In Aalborg restaurants like Skagen Fiskerestaurant or Ubat have been found to be the right market area.

In business model canvas words, this means that the initial target is a **niche marke**t where, once the product has been established, can grow into a **segmented market** where the needs are slightly different (the demands on the amount of leafy greens and microgreens change).

2. Customer relationships

This component of the business model canvas is where the relationship with the customer is established. Here it is decided how the interaction with the customer will be while they have the product. [1]

Here, the idea is that the company will provide the restaurants with **personal assistance** to install the product and assist them with any problems/ doubts that they have. Furthermore, an **automated service** is provided in the sense that the product will be mostly automated. At the same time, the company will provide the restaurants, monthly, with the growing mediums and seeds that they need.

3. Channels0

This component of the business model canvas explains how the company will reach out, communicate and raise awareness of the product. [1]

This will be done through company-**owned channels** like a website, social media, and if possible, open vegetable markets where different chefs from restaurants go to buy vegetables. The idea would be to stand there to provide them with fresh greens and introduce them to the product.

4. Revenue streams

In this part of the model canvas, the source from which the company makes money is discussed. The idea is to have **recurring revenue**, this means that the company will receive ongoing payments. [1] The reason for this is that, during the interviews, it was noticed that the chefs were a bit worried of investing in such a big product with the uncertainties that there are in the restaurant business.

The idea is to **rent/ lease** the product. This allows the restaurant to return the product if it is not for them or if it closes. Furthermore, the product is divided into different modules meaning that the restaurant can slowly incorporate it into their day-to-day or increase/ decrease the size if necessary, then the price would increase/ decrease accordingly. The second revenue stream is a subscription fee so that the company will on, a monthly basis, deliver growing mediums and seeds to the restaurant.

5. Key activities

This component of the business model canvas is where the necessary activities so that the business works are discussed. There are three main categories in this case: [1]

Production: The idea for production is to find all the components in Denmark. The reason for this is the concept of the product wanting to reduce waste and therefore, the company also wants to keep at a minimum the CO2e emissions from manufacturing the product. This means Danish suppliers for wood, plastic trays, and electronics. If this is not a possibility, then the search would be expanded to Europe and as a final resort, the search would be global. This last one is not desired because of the emissions when transporting the product.

Problem-solving: Research will be needed too in order to solve any possible inconveniences that have not been foreseen while developing the product.

Platform/ network: Because the idea is that the product can be used by multiple staff in the restaurant, an app is needed so that they are all aware of the different stages the plants are at, and the readings from different sensors if there are any. This one will need to be updated every so often.

6. Key resources

In order to perform the key activities from the previous section, some key resources are needed. In this part of the model canvas, these resources are explored. [1]

Physical: Physical resources are needed in order to manufacture the product. This includes machinery, the material, and the building in which this takes place among other resources.

Human: In order to assemble and produce the product, employees are needed. These employees are found along the whole chain. They include the designers, marketing staff, production staff, etc.

Financial: Financial resources are also needed so that this business can come to life. Here, investors will be needed.

7. Key partners

This part of the business model canvas explores partnerships with external companies so that the key activities can be performed. [1]

A **strategic alliance** would be needed with the restaurants so that it is possible to obtain information from them in order to develop the product. Furthermore, having a hydroponic farmer on board will aid with the knowledge necessary to ensure the product is providing the most amount of vegetables in the fastest time possible. In this case, a **business venture** has also been found with two entrepreneurs looking to penetrate the vertical farming market for restaurants.

8. Cost structure

In this part of the business model canvas, the different costs that are necessary to run and maintain the business model are identified. This includes the salaries for the different employees, the rent or payment for the different machinery, the costs of the different materials and products, transportation fees, etc.

9. Value proposition

In this part of the business model canvas, the values that make the product unique are presented. These **values** are the adaptability, in size and amount along with the option of switching out a tray of microgreens for one of leafy greens and vice-versa. The freshness of the greens, not only microgreens but also leafy greens. The space on one product to germinate and store the mediums and seeds. The gradual implementation of the product by adding modules allowing the restaurant to slowly invest in the product. The reduction of waste being produced in restaurants.

The visual representation that combines all the above information can be seen on the table bellow:

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

This activity gives a good visual representation of what is needed to get the business up and running, aswell as a good overview of what it will look like.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

Important notes/observations: *Here you can write the important points and the new/updated requirements/demands and wishes, and how they were found*

References: *Here you add the references*

[1]: https://creately.com/guides/business-model-canvas-explained/ (25/04)

Appendix 20 - Price calculations

Objective: *Here you briefly state the intention, plan, method, and desired result for the activity*

The aim of this appendix is to calculate the price of the product. To do so, many assumptions and educated guesses have been used.

Experiment/data: *Here you put in a sketch, storyboard, diagrams, photo of mock-up or experiment, rendering of 3D model, interview, etc, including own explanatory comments, analysis and perhaps evaluation*

The calculations cannot be fitted into a printing format so a link is left here. In the digital exam a digital format of the excel is left.

https://docs.google.com/spreadsheets/d/1BwYiY_7eRQQb0fyXLEjlB7V7nbNeprPf2abUOQFc0nU/edit?usp=sharing

Evaluate: *Summarise and evaluation. Did the activity meet the objectives and to what extent? How did you evaluate? Did you use external feedback, calculations, estimations, etc.? And what is the validity of the result?*

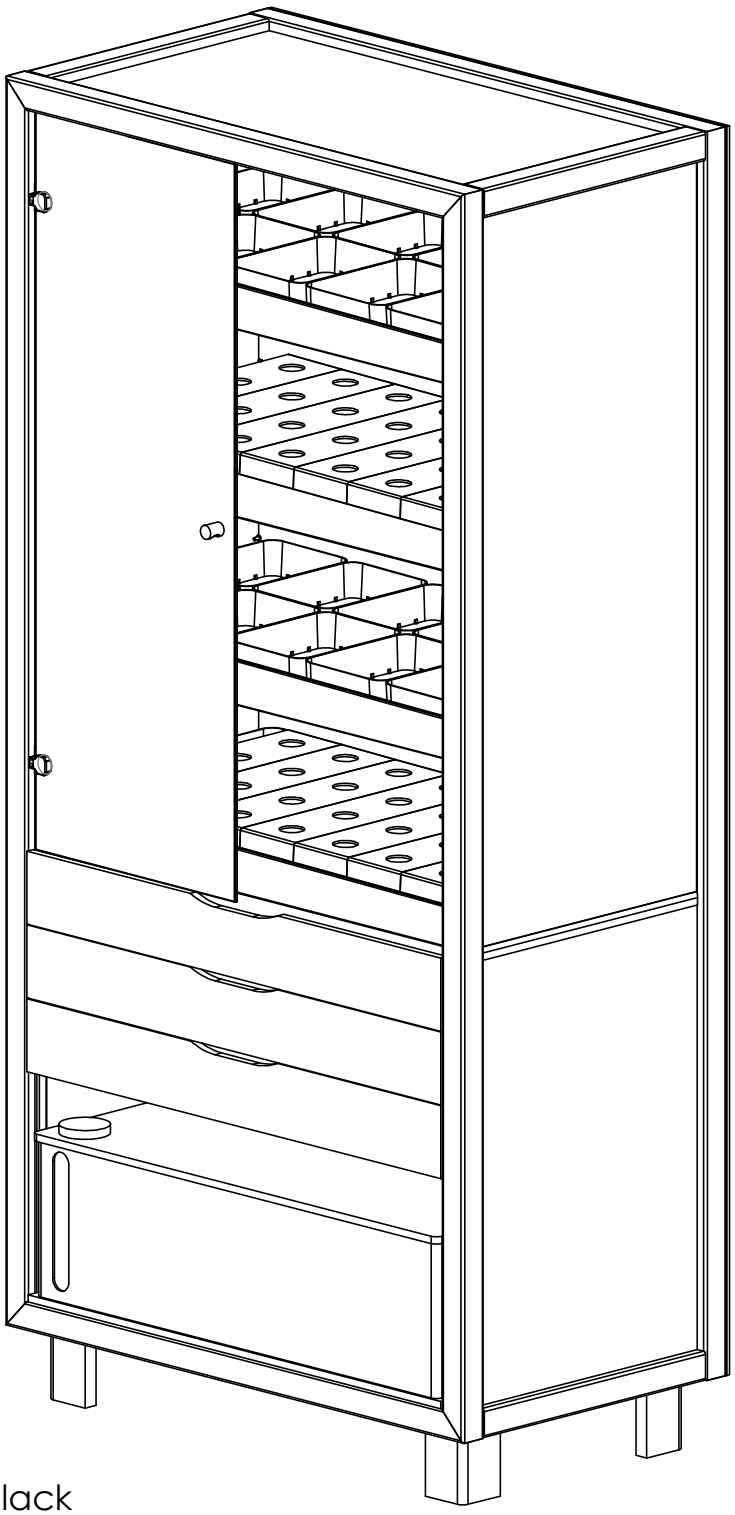
The calculations are believed to be an educated guess and only used for an estimation. There are many assumptions used to calculate the price of the product. In here, it is also possible to find the NVP of the product.

Reflection: *What did you learn? Do you need to change method, mode, approach or revise the objectives, specification or criteria? What is the next move?*

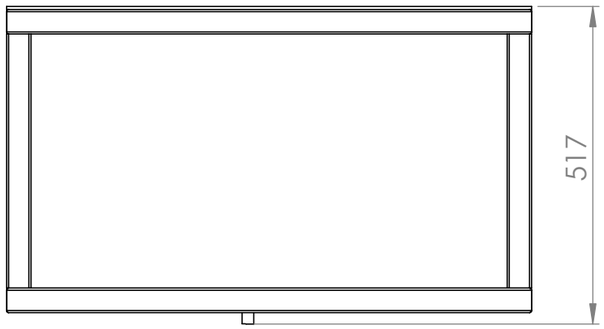
To obtain a more detailed number, much more information is needed and it is really hard to get access to it. Stuff has been left out like the varnish for the material and the fertiliser.

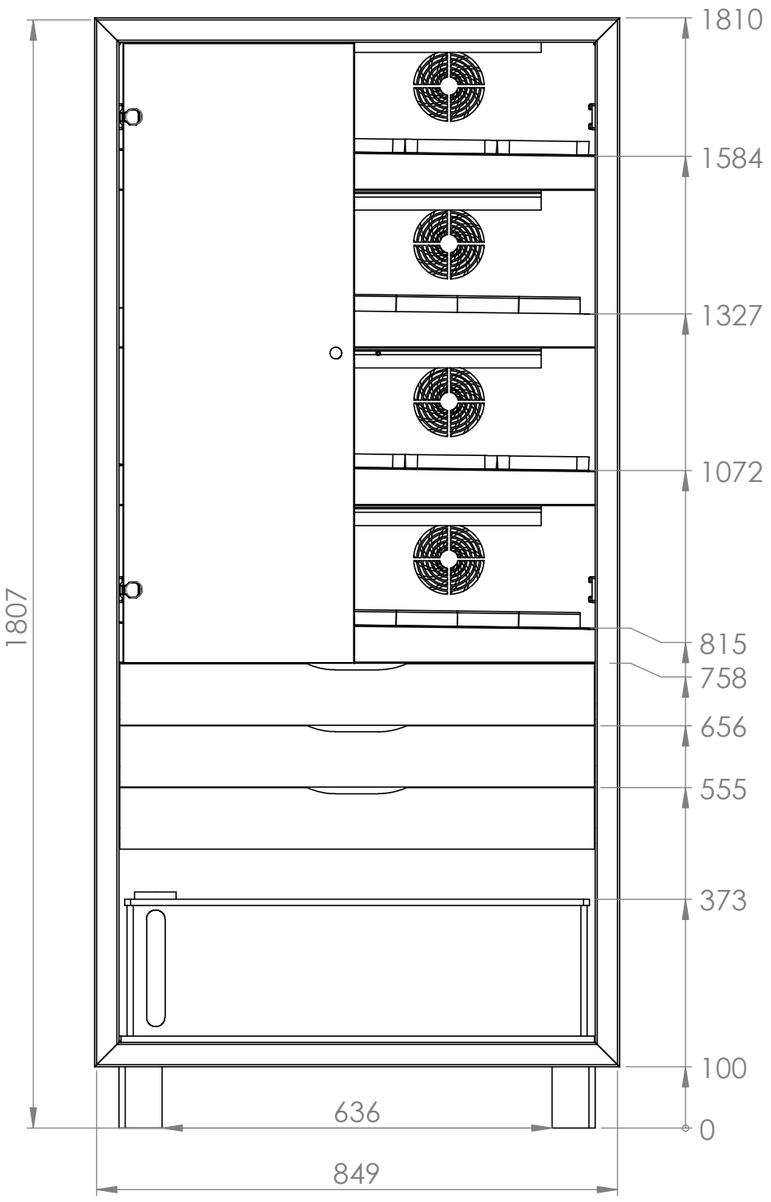
Technical drawings Vertigarden

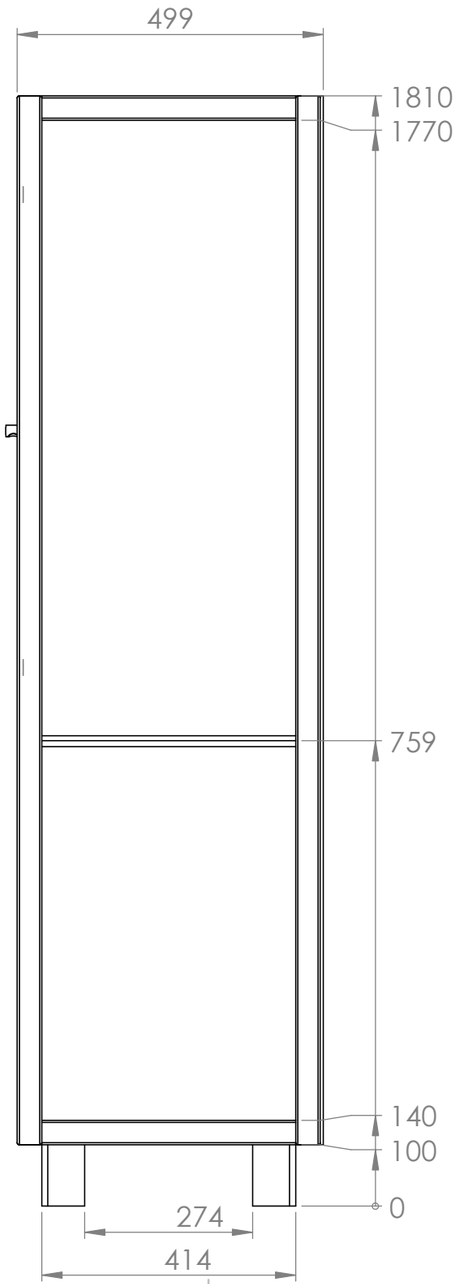
/ AALBORG UNIVERSITY
/ SPRING 2023
/ INDUSTRIAL DESIGN
/ MSC04-ID012
Eiden Arredondo Harmen
Laura Moreno Huang

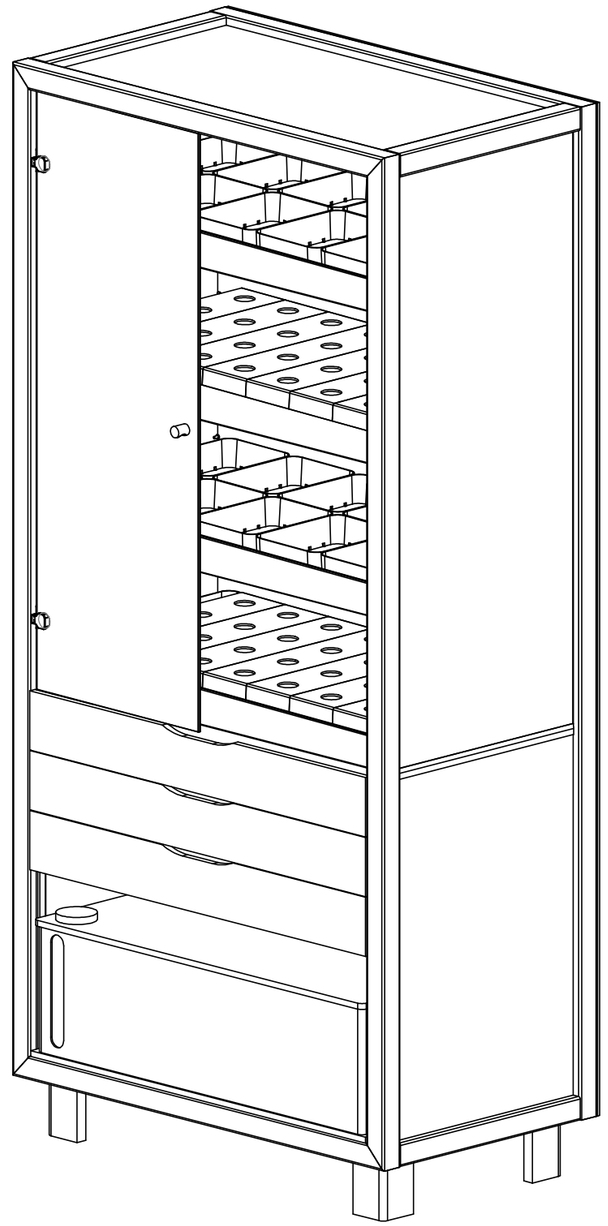


Disclaimer:
Some components lack measurements, which can only be measured if the 3D model is available due to non-geometric conditions.



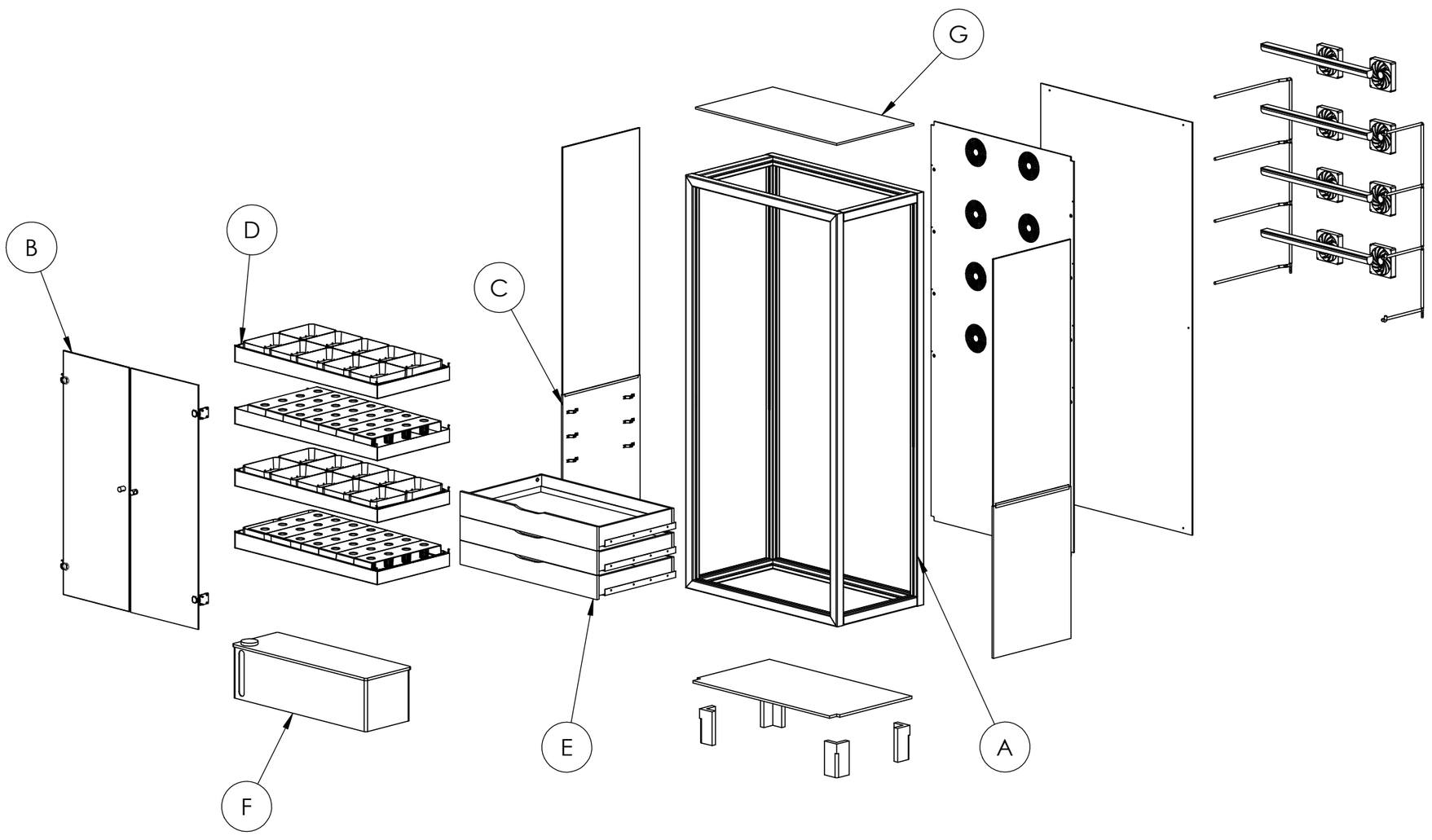




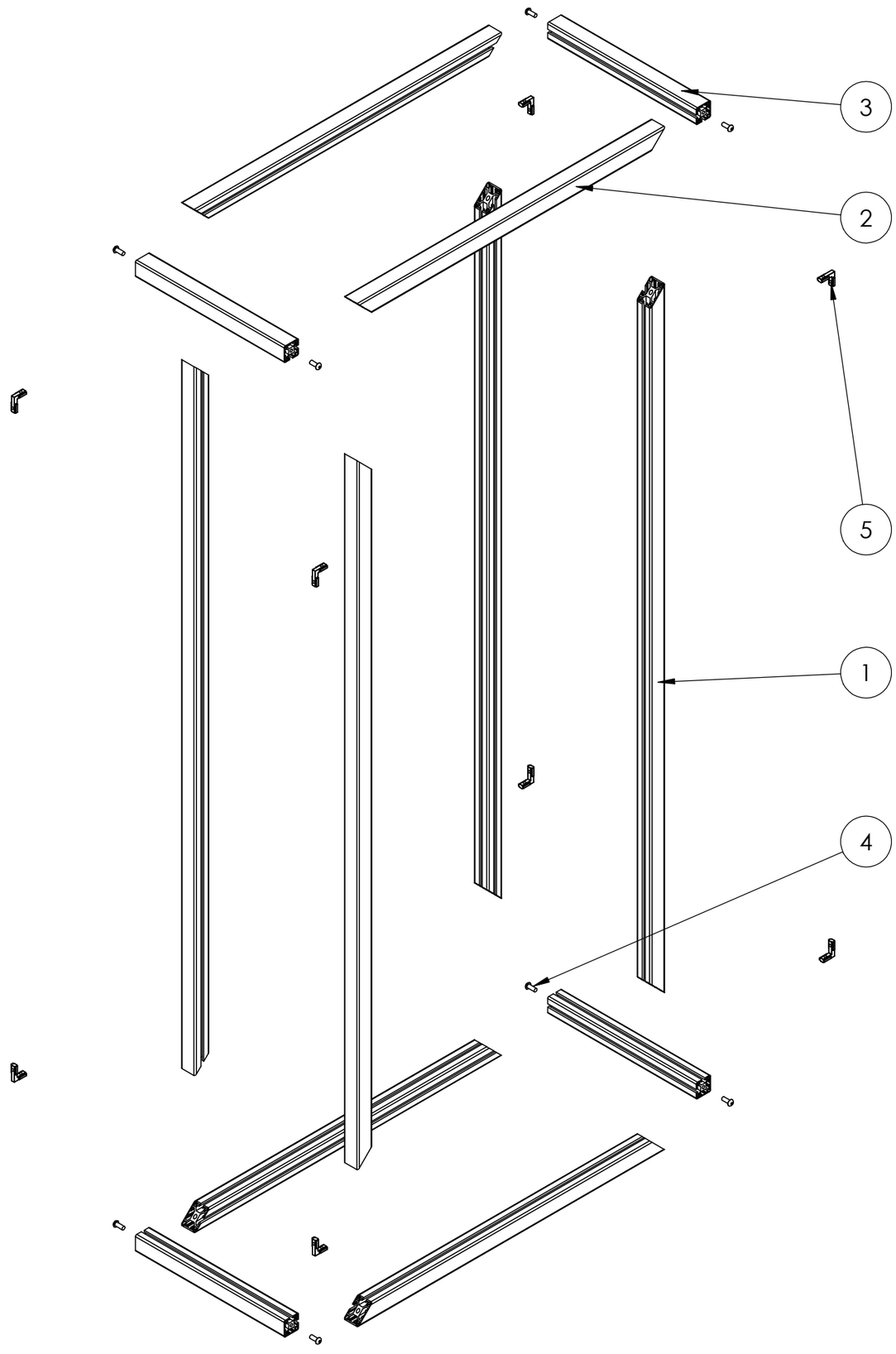


General view	Full product overview
Vertigarden	Date: 25/05/23
Size: A3	Scale: 1:10

Sub-assembly letter	
A	Main frame assembly
B	Door assembly
C	Rail panel assembly
D	Tray assembly
E	Drawer assembly
F	Water tank assembly
G	Components that don't requirer assembly

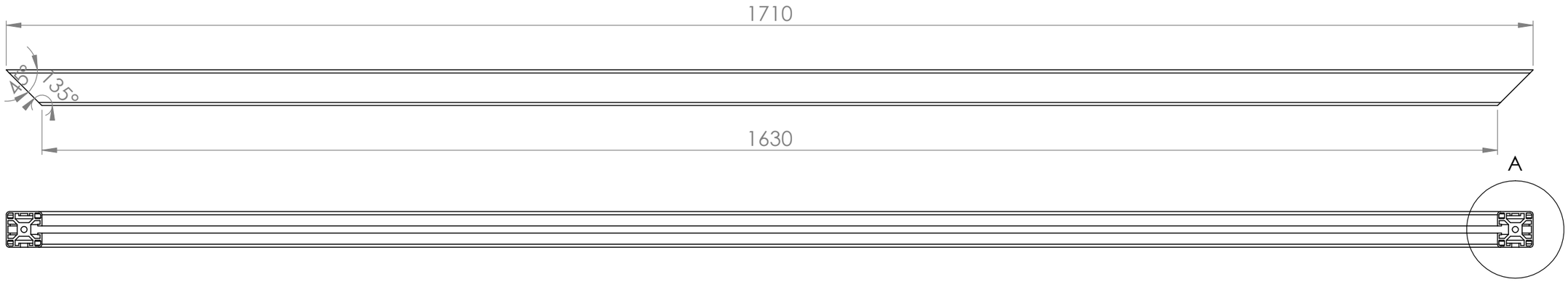


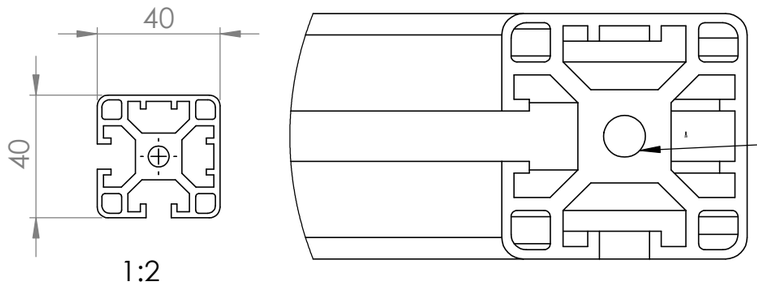
Subassembly distribution



ITEM NO.	PART NUMBER	Material	DESCRIPTION	QTY.
1	Aluminium_Profile_40x40_2_Open_1710: A, B, C, D.	Aluminium	Extrusion	4
2	Aluminium_Profile_40x40_2_Open_850 : A, B,C .	Aluminium	Extrusion	4
3	Aluminium_Profile_40x40_2_Open_450	Aluminium	Extrusion	4
4	M8_Bolt	-	-	8
5	Inside_Bracket	Aluminium	-	8

Exploaded view	Main frame
Vertigarden	Date: 25/05/23
Size: A3	Scale: 1:10



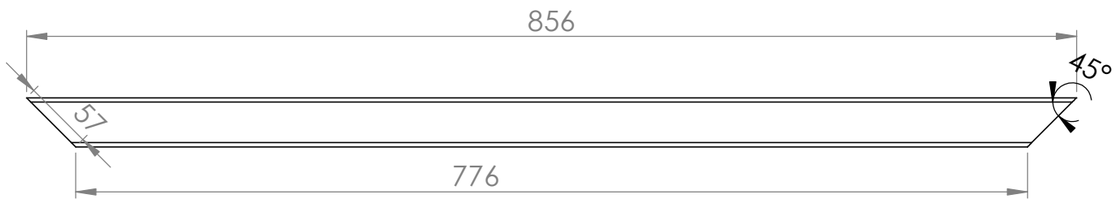


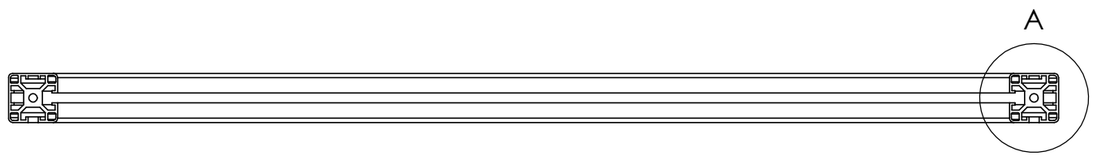
1:2

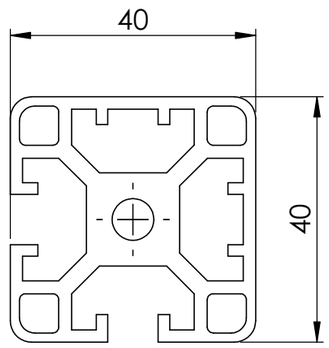
DETAIL A
SCALE 1 : 1

IMPORTANT !
Please note the direction of the cut

Part name: Aluminium profile 1710	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: A. 1	Date: 25/05/23
Material: Aluminium	Scale: 1:5







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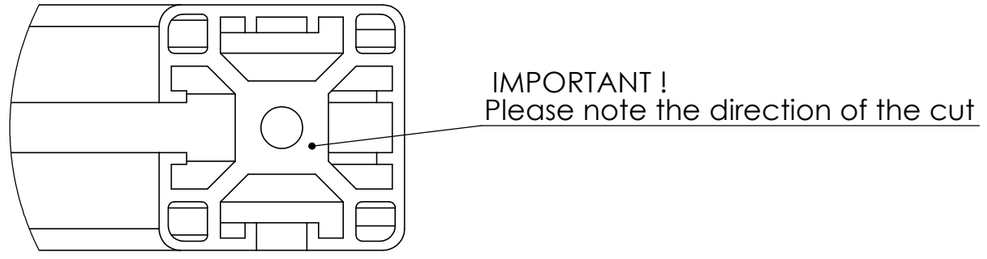
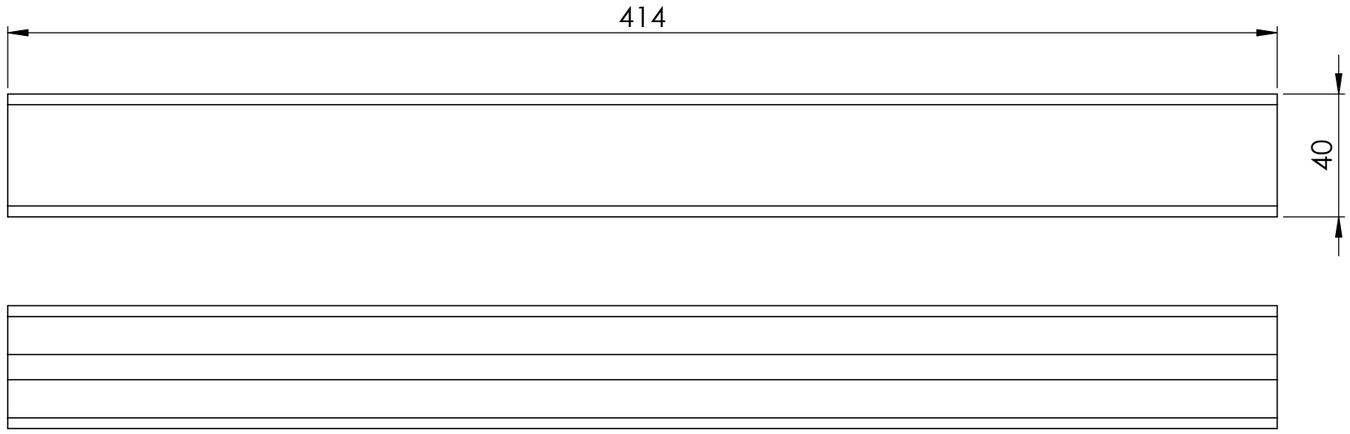


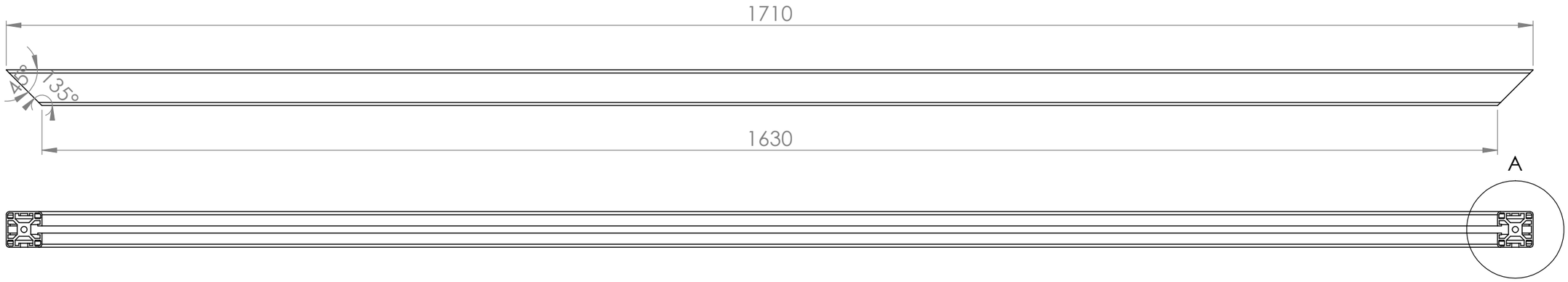
DETAIL A
SCALE 1 : 1

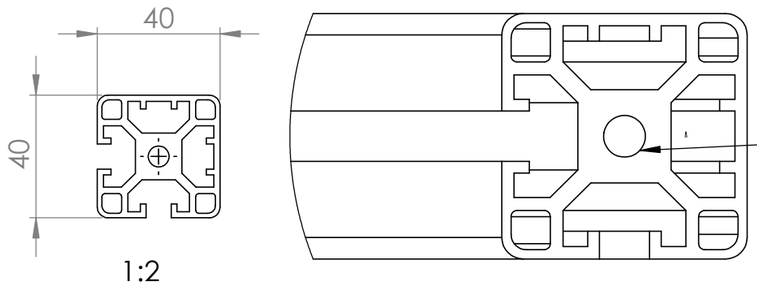
Part name: Aluminium profile 850	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: A. 2	Date: 25/05/23
Material: Aluminium	Scale: 1:5



1:1

Part name: Aluminium profile 450	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: A. 3	Date: 25/05/23
Material: Aluminium	Scale: 1:2



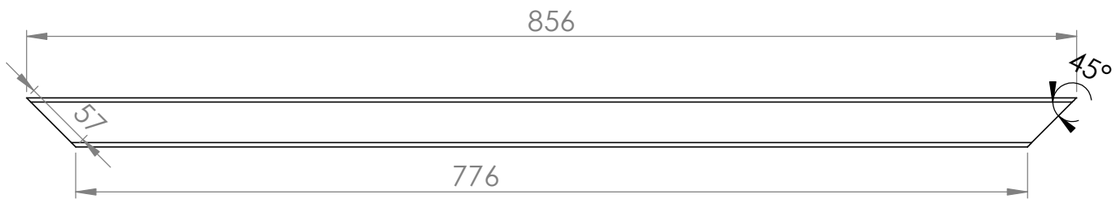


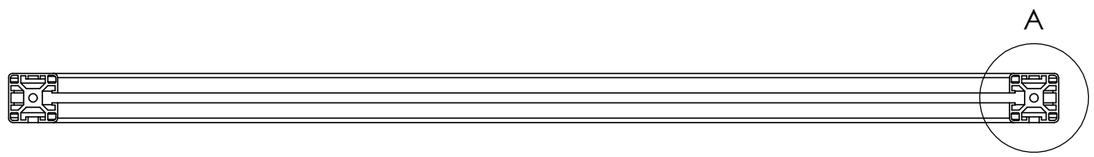
1:2

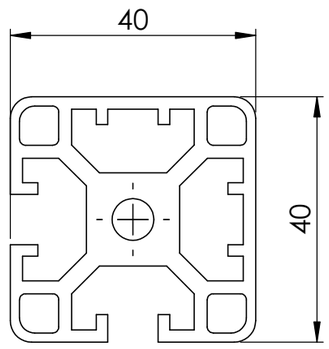
DETAIL A
SCALE 1 : 1

IMPORTANT !
Please note the direction of the cut

Part name: Aluminium profile 1710	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: A. 1	Date: 25/05/23
Material: Aluminium	Scale: 1:5







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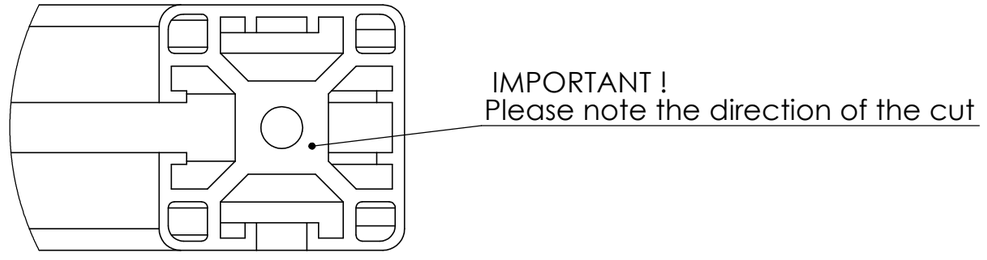
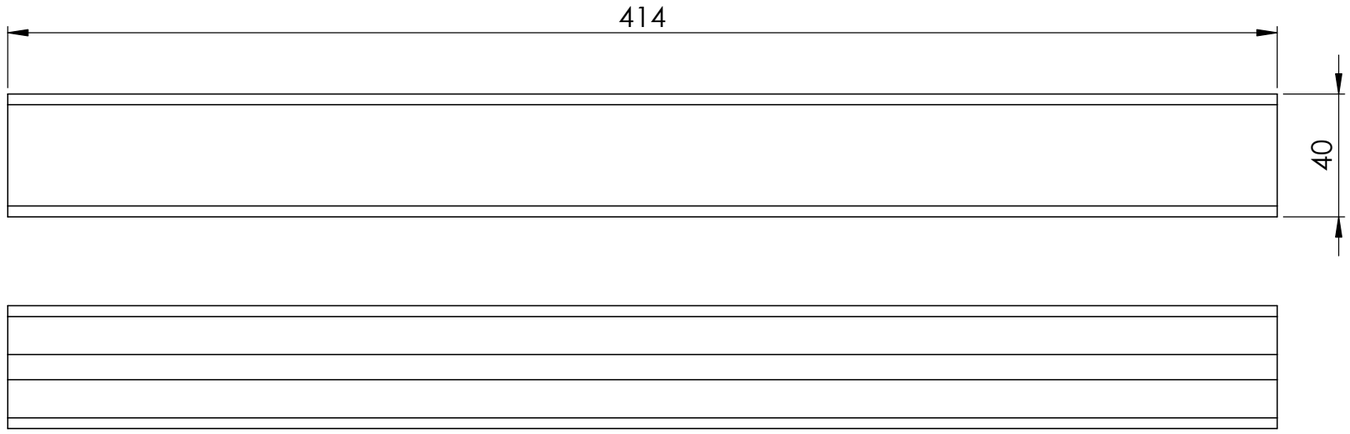


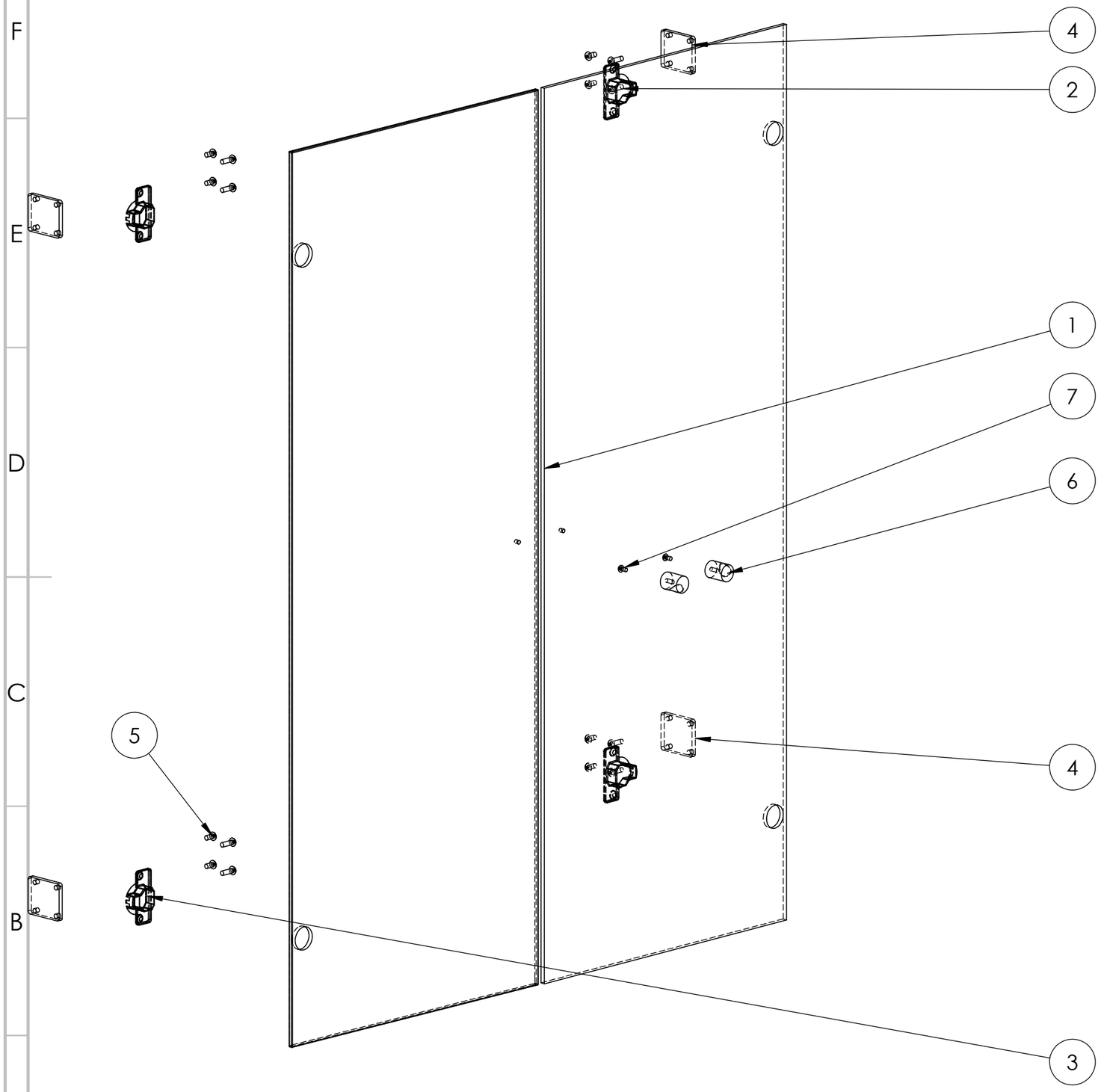
DETAIL A
SCALE 1 : 1

Part name: Aluminium profile 850	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: A. 2	Date: 25/05/23
Material: Aluminium	Scale: 1:5



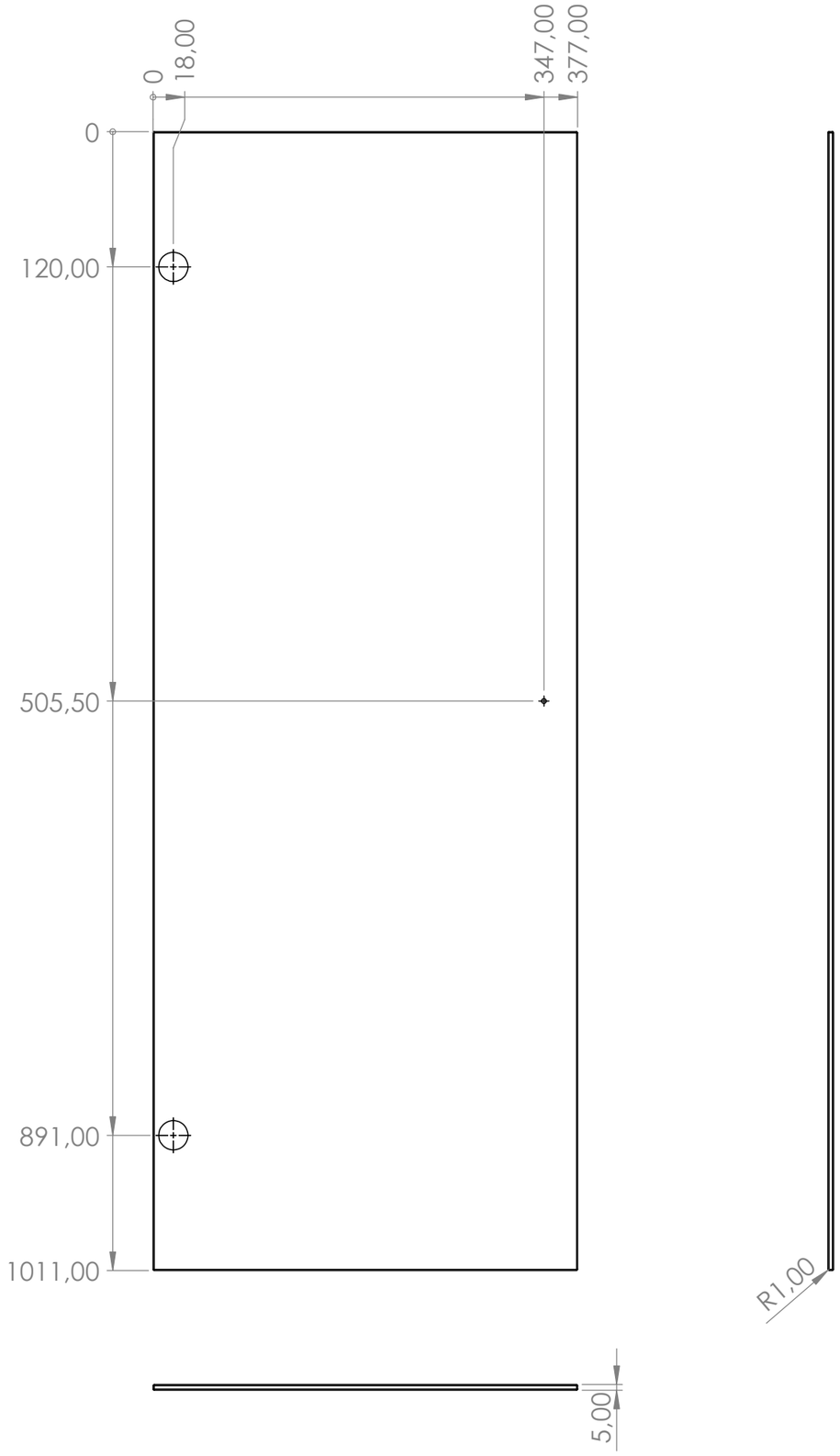
1:1

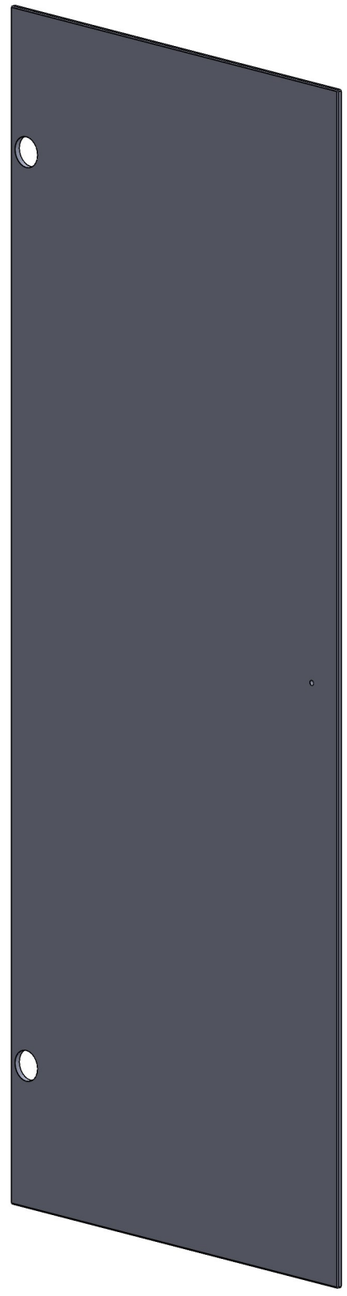
Part name: Aluminium profile 450	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: A. 3	Date: 25/05/23
Material: Aluminium	Scale: 1:2



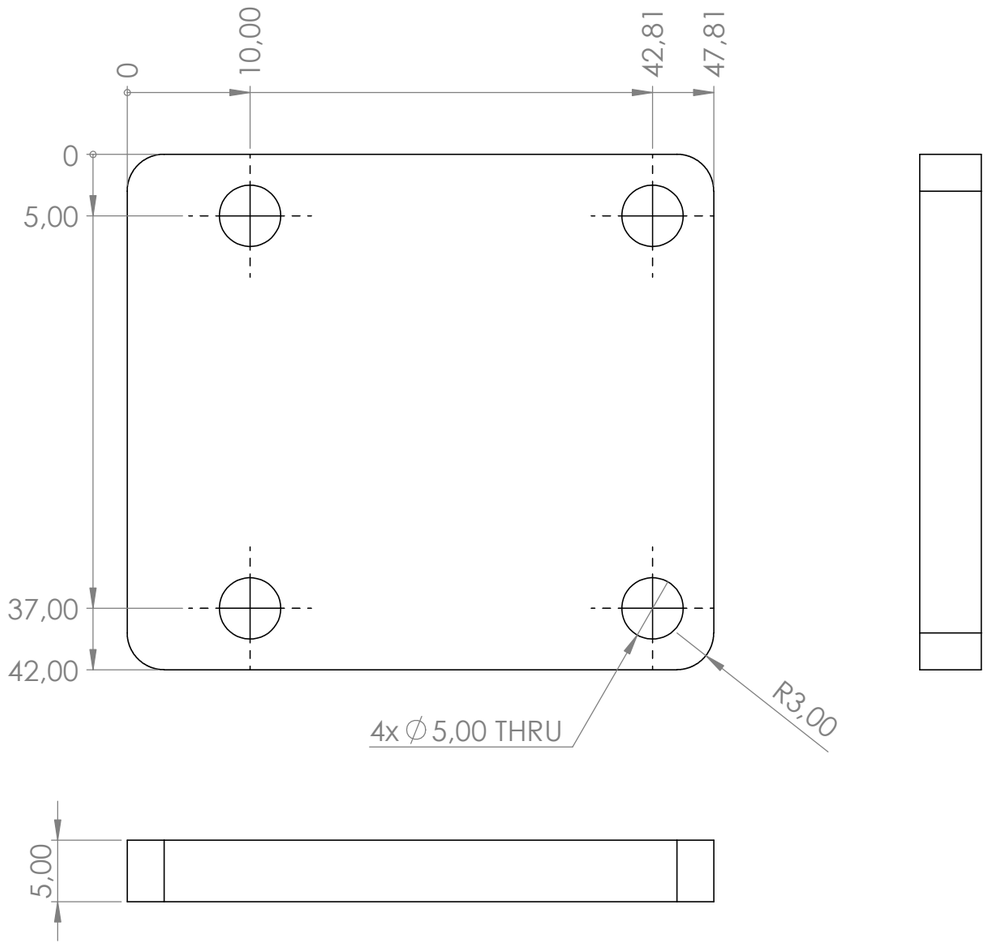
ITEM NO.	PART NUMBER	Material	Production	QTY.
1	Glass_Door	Glass	-	2
2	M5_15_Bolt		-	8
3	Hinge part 1	-	-	4
4	Hinge_Plate	-	-	4
5	M5_10_Bolt	-	-	8
6	Door_Knob	Black aluminium	-	2
7	M4_bolt_8mm	-	-	2

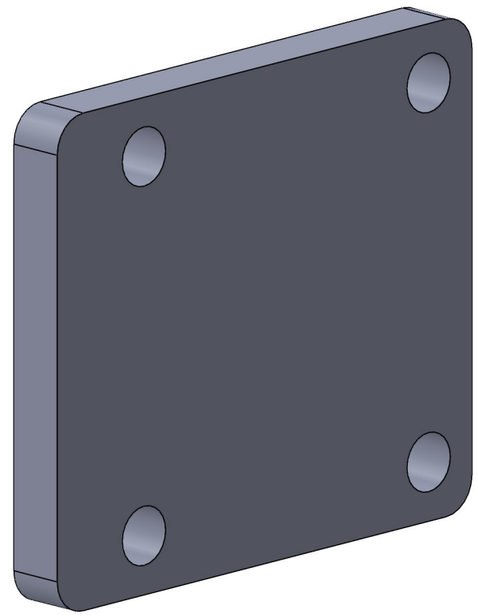
Exploaded view	Glass doors
Vertigarden	Date: 25/05/23
Size: A3	Scale: 1:5





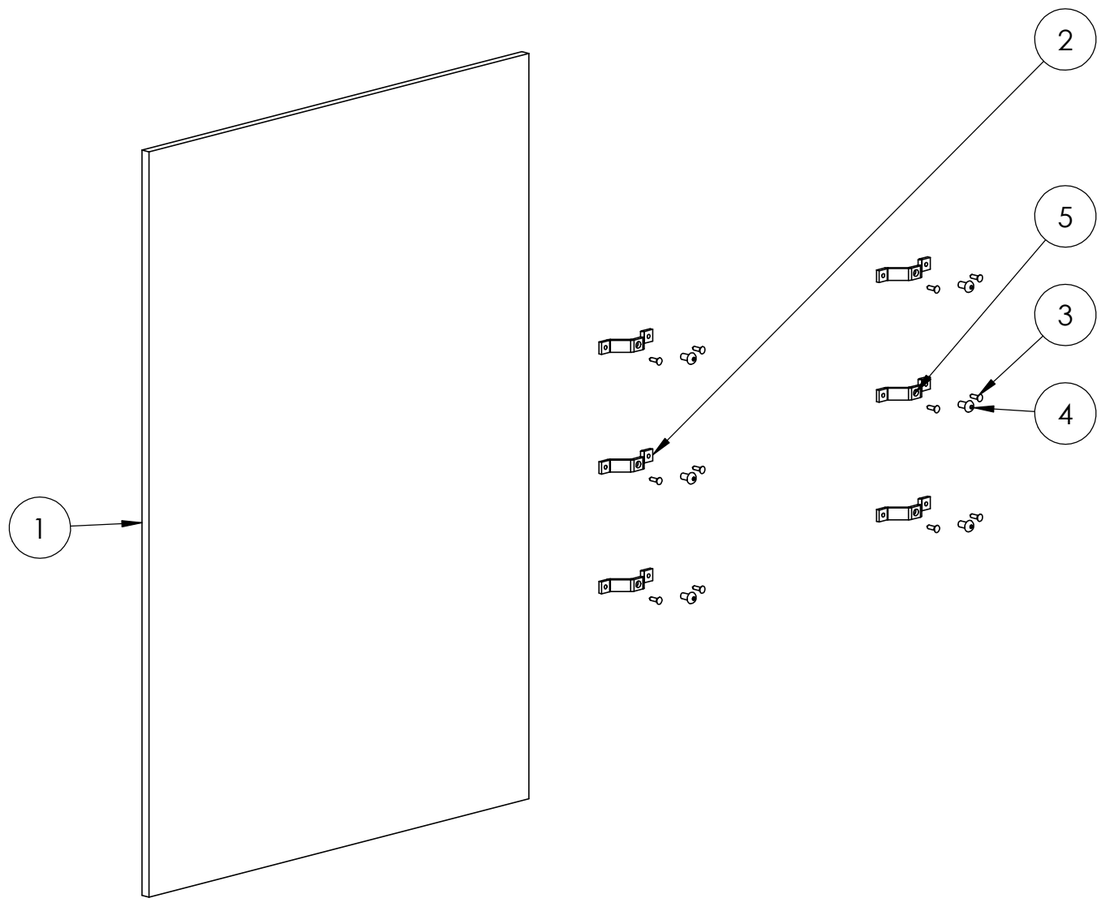
Part name: Glass door	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: B. 1	Date: 25/05/23
Material: Glass	Scale: 1:5



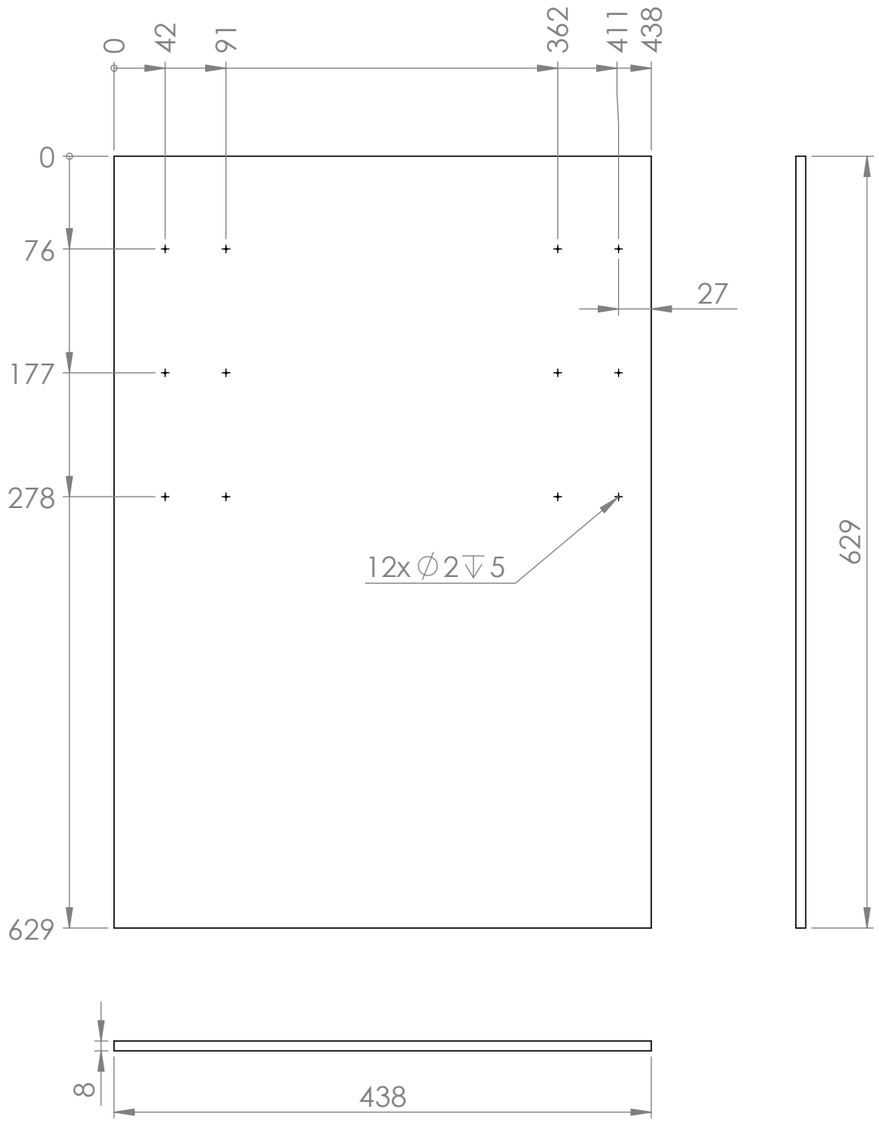


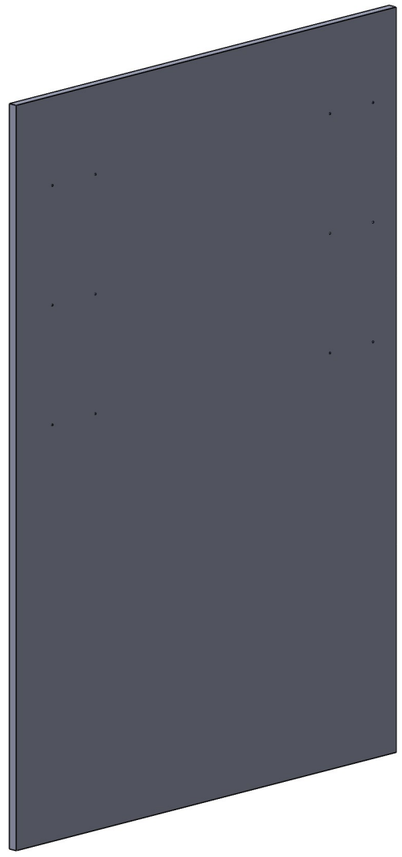
Part name: Hinge plate	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: B. 4	Date: 25/05/23
Material: Aluminium	Scale: 2:1

ITEM NO.	PART NUMBER	Material	Production	QTY.
1	Wooden_panel_sides	Okoume	CNC	1
2	Metal spacers	Aluminium	Water ject cutter	6
3	Screw_9.5	-	-	12
4	M5_10_Bolt	-	-	6
5	M5_Nut	-	-	6

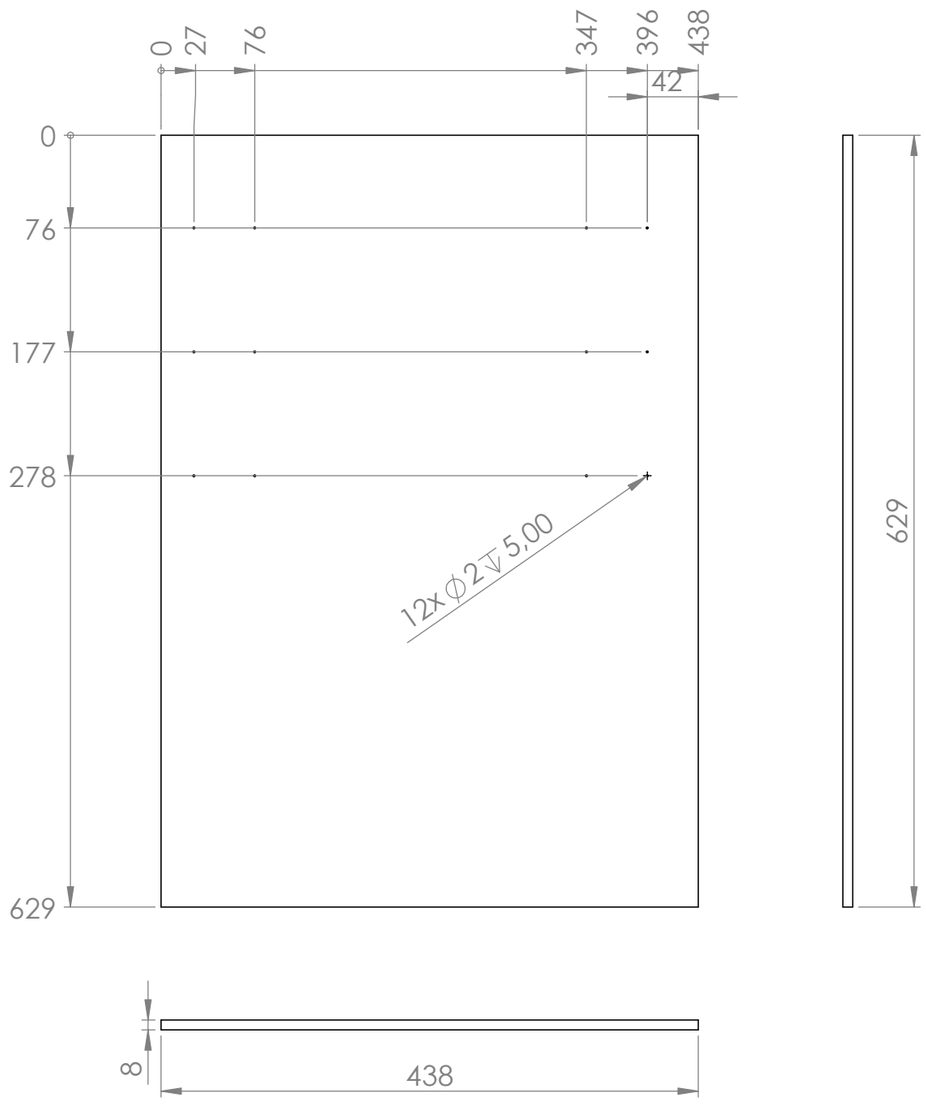


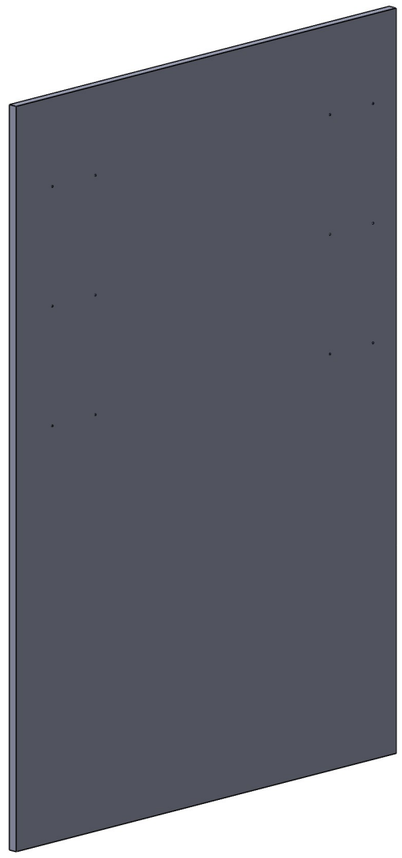
Exploaded view	Side Wooden panels
Vertigarden	Date: 25/05/23
Size: A3	Scale: 1:5



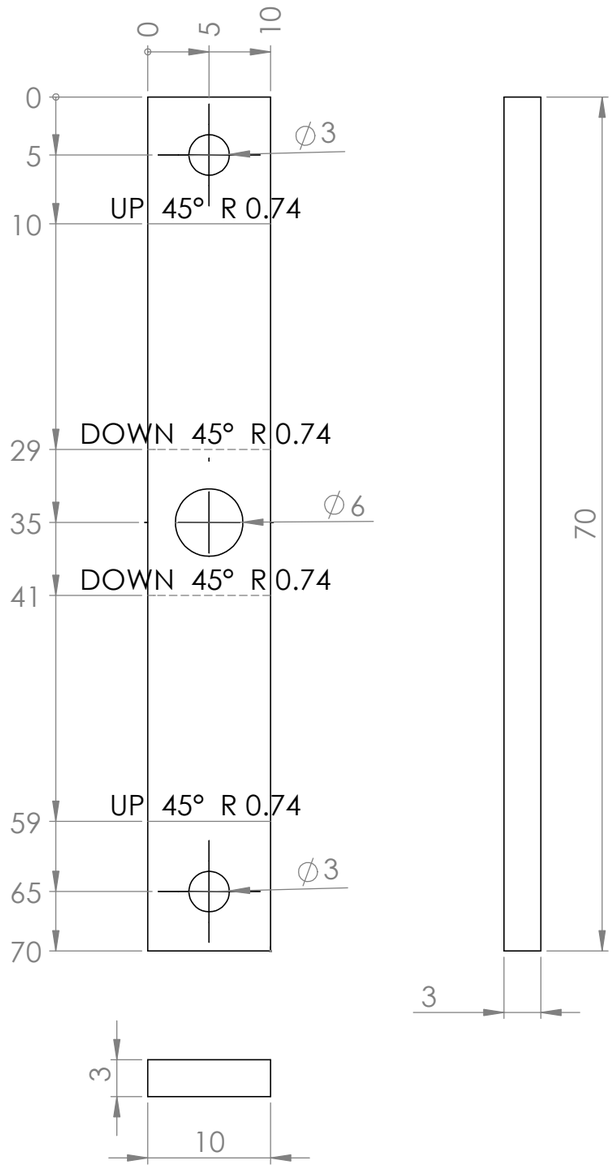


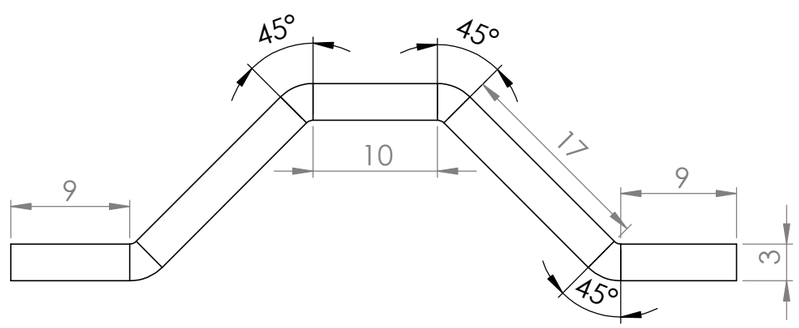
Part name: Wooden panel rigth side	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: C. 1.0	Date: 25/05/23
Material: Oukome plywood	Scale: 1:5

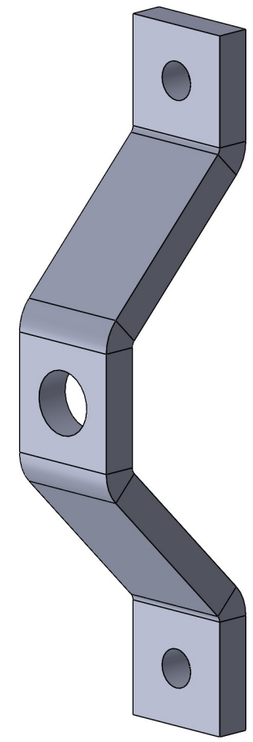




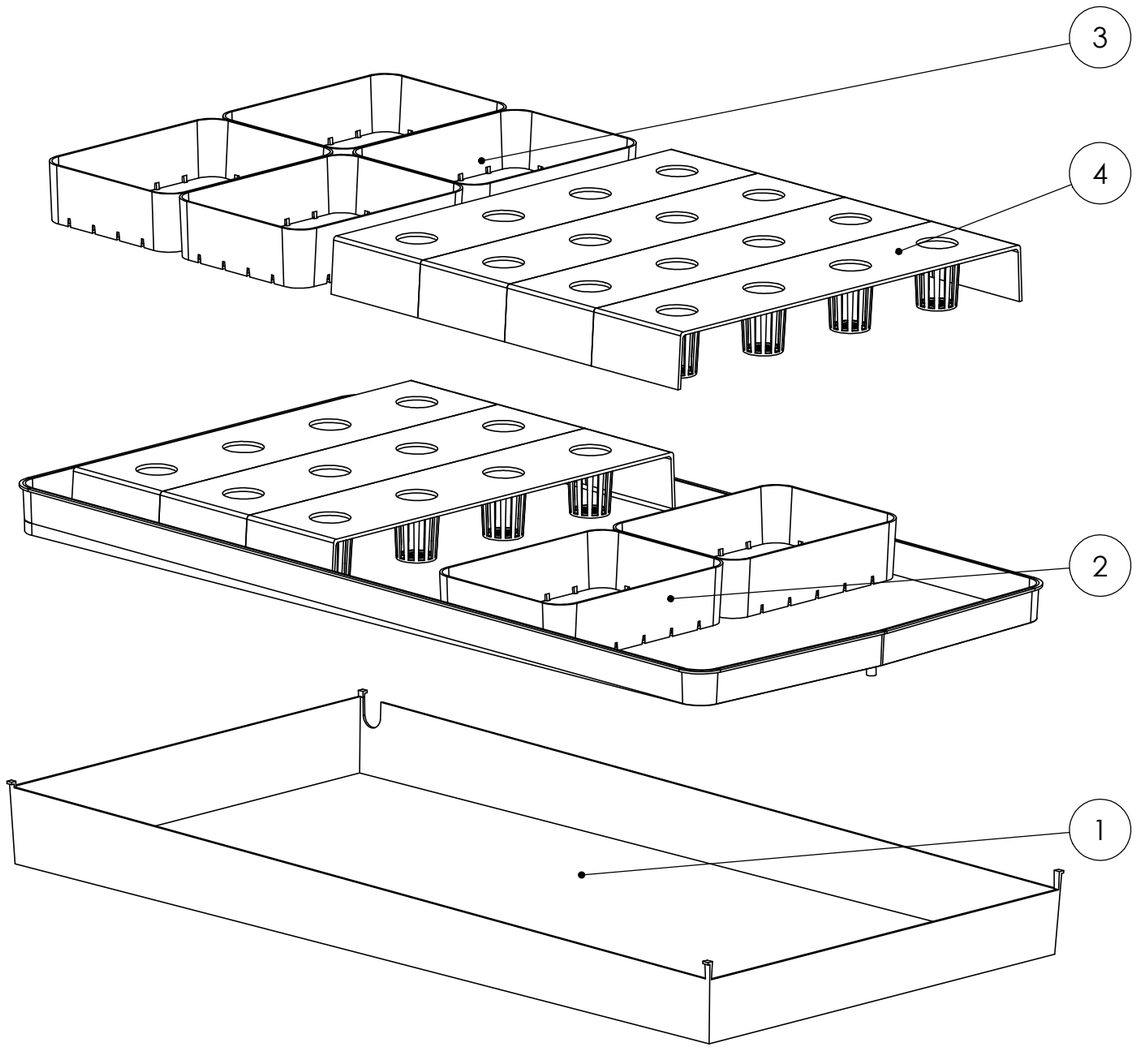
Part name: Wooden panel left side	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: C. 1.1	Date: 25/05/23
Material: Oukome plywood	Scale: 1:5





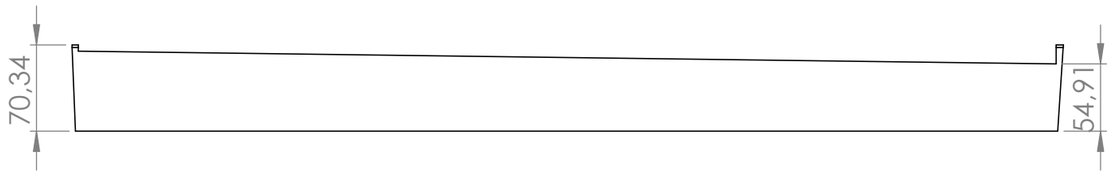


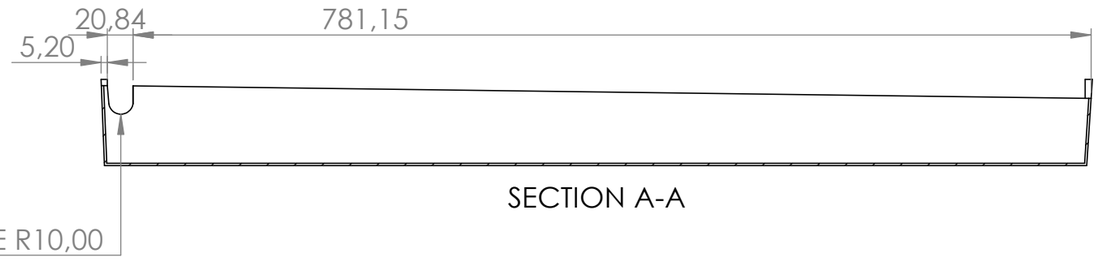
Part name: Metal spacers	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: C. 2	Date: 25/05/23
Material: Aluminium	Scale: 2:1



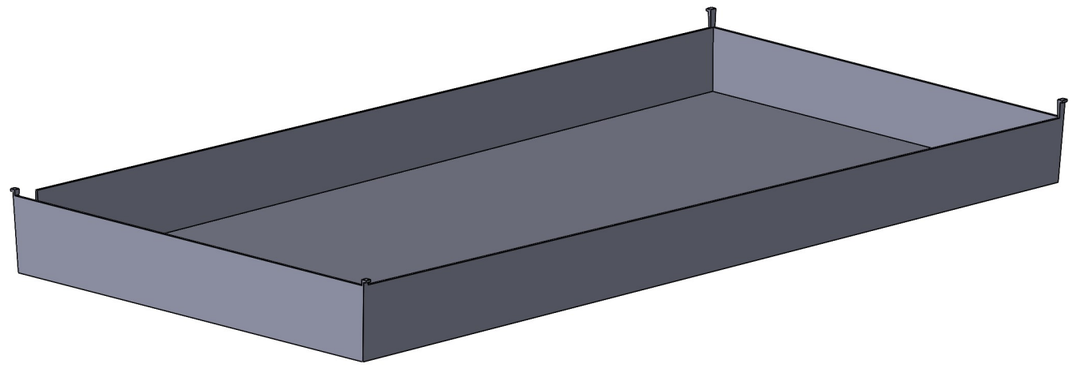
ITEM NO.	PART NUMBER	Material	Process	QTY.
1	Plastic_Tray	Terralene	Thermoforming	1
2	DrainingTray	Terralene	Thermoforming	1
3	MicrogreenTrays	Terralene	Thermoforming	10
4	LeafyGreenTray	Terralene	Thermoforming	7

Exploaded view	Plastic trays
Vertigarden	Date: 25/05/23
Size: A3	Scale: 1:5

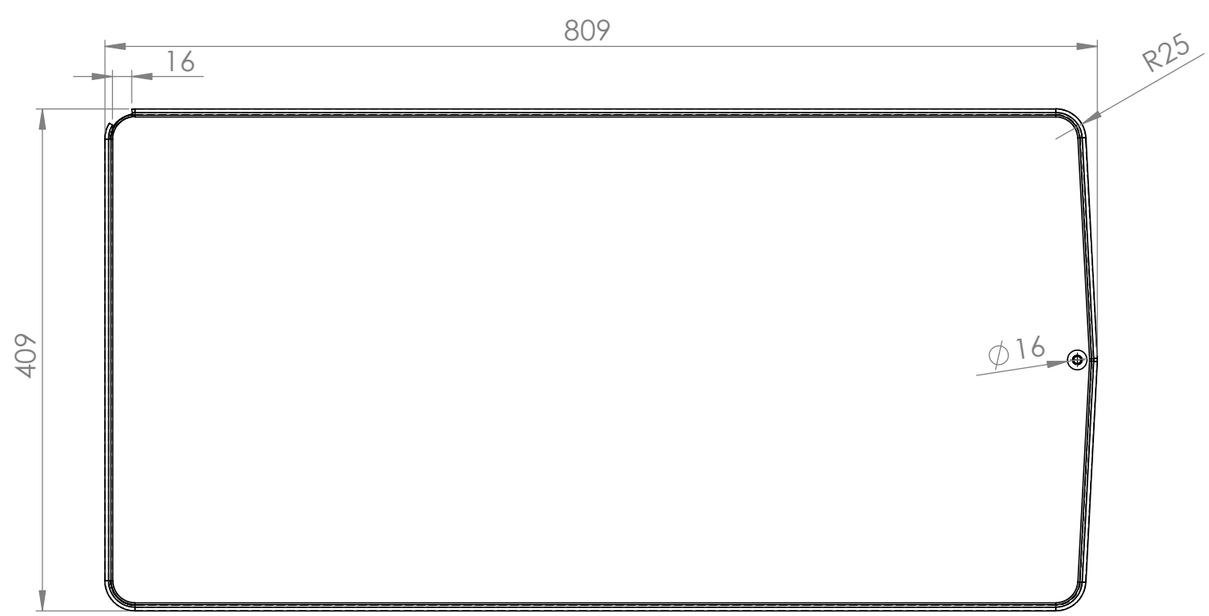


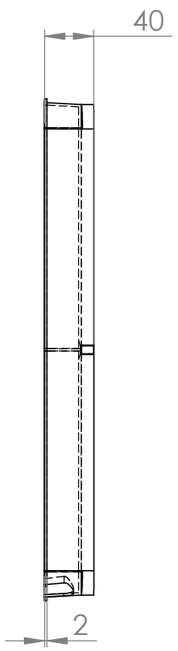


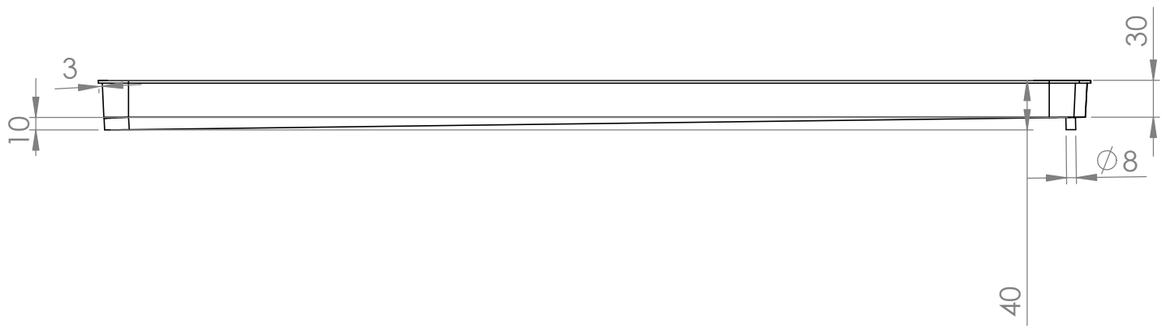
SECTION A-A

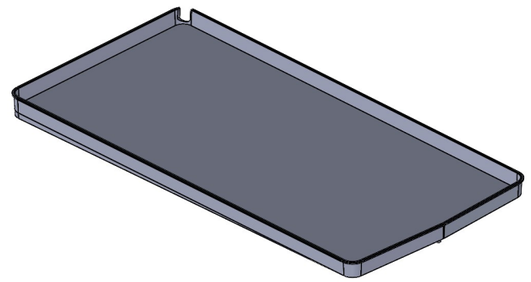


Part name: Plastic Suport tray	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: D. 1	Date: 25/05/23
Material: Terralene	Scale: 1:5



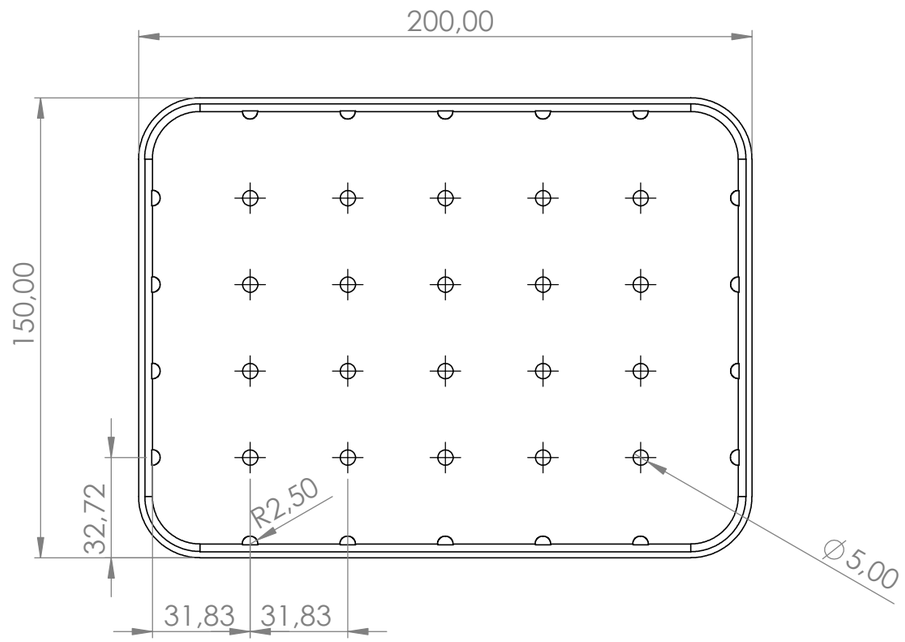


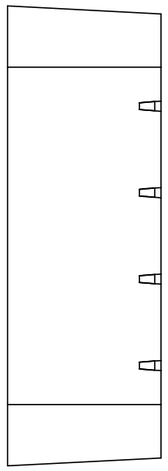


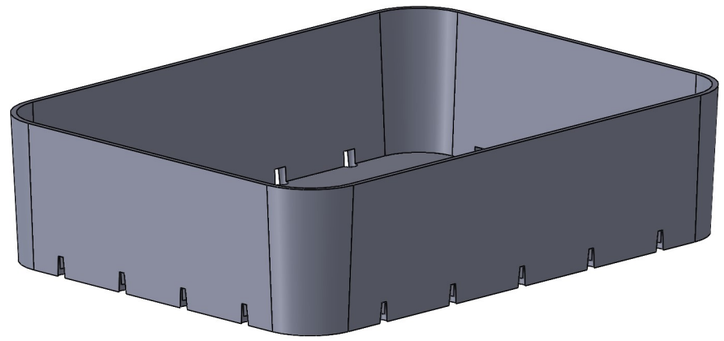


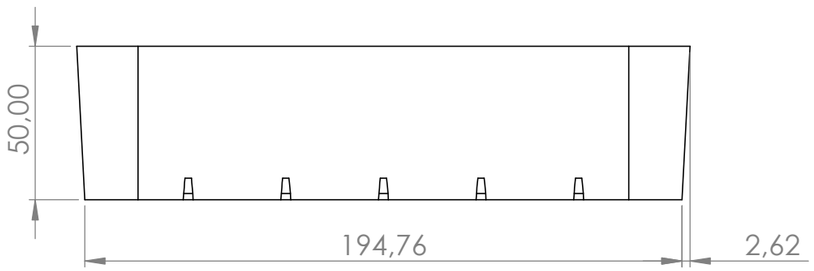
Scale 1:10

Part name: Draining tray	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: D. 2	Date: 25/05/23
Material: Oukome plywood	Scale: 1:5

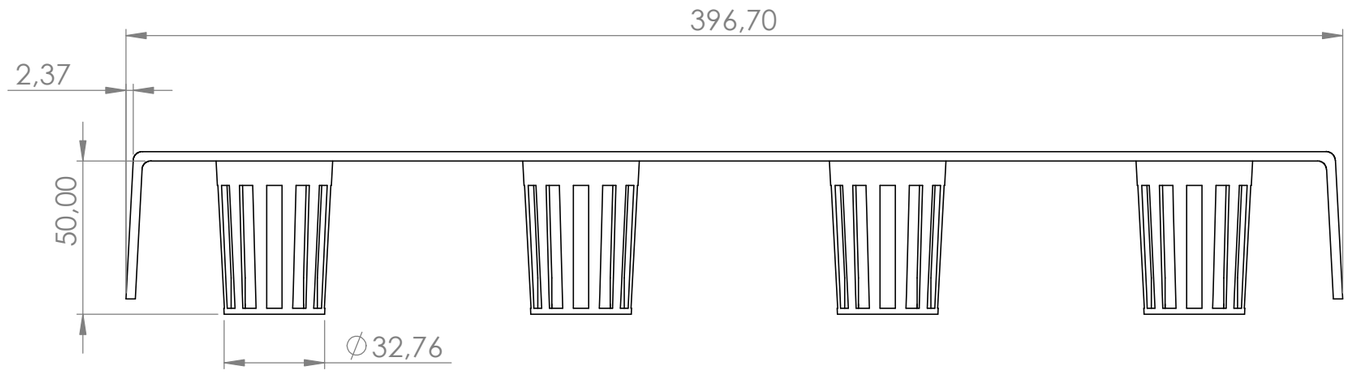


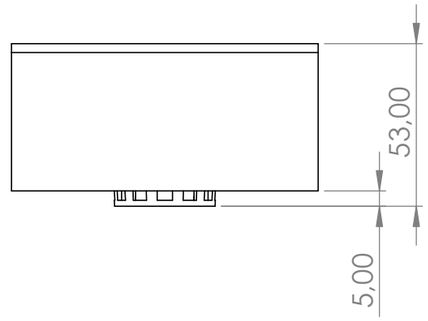


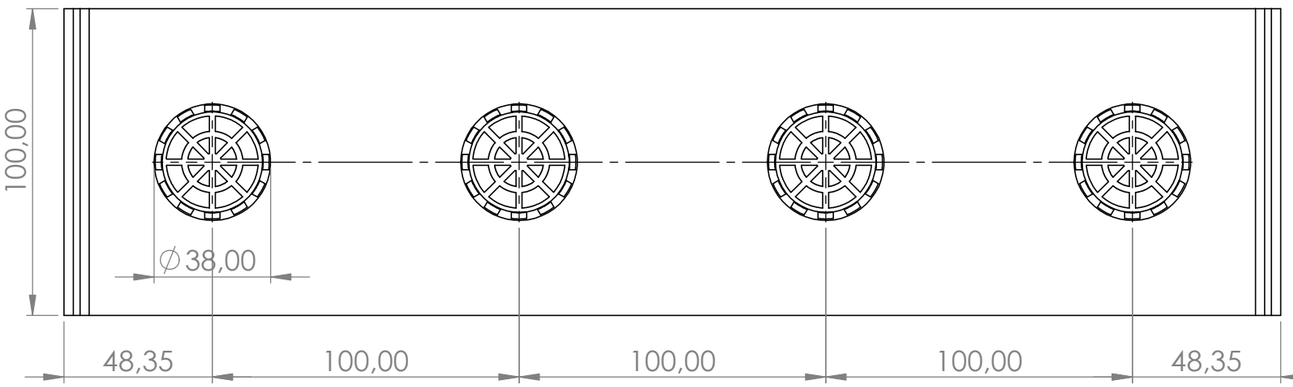


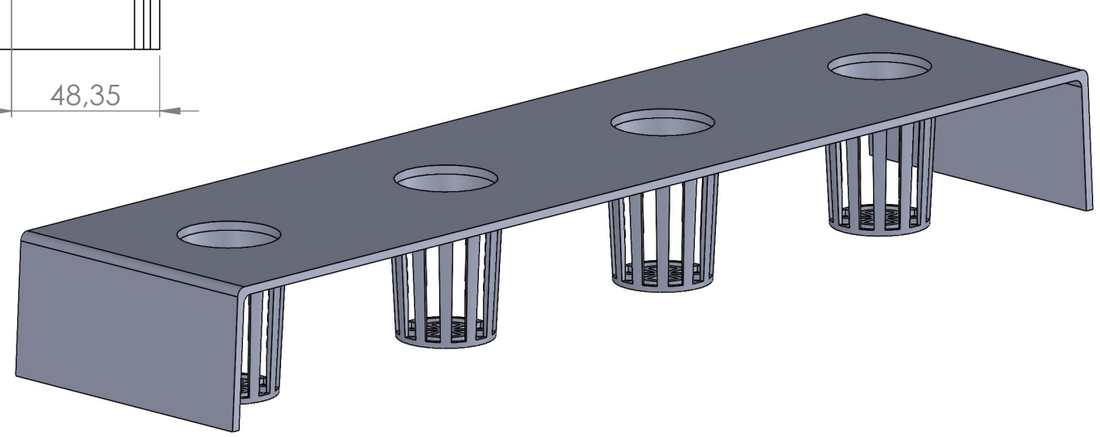


Part name: Microgreen tray	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: D. 3	Date: 25/05/23
Material: Terralene	Scale: 1:2



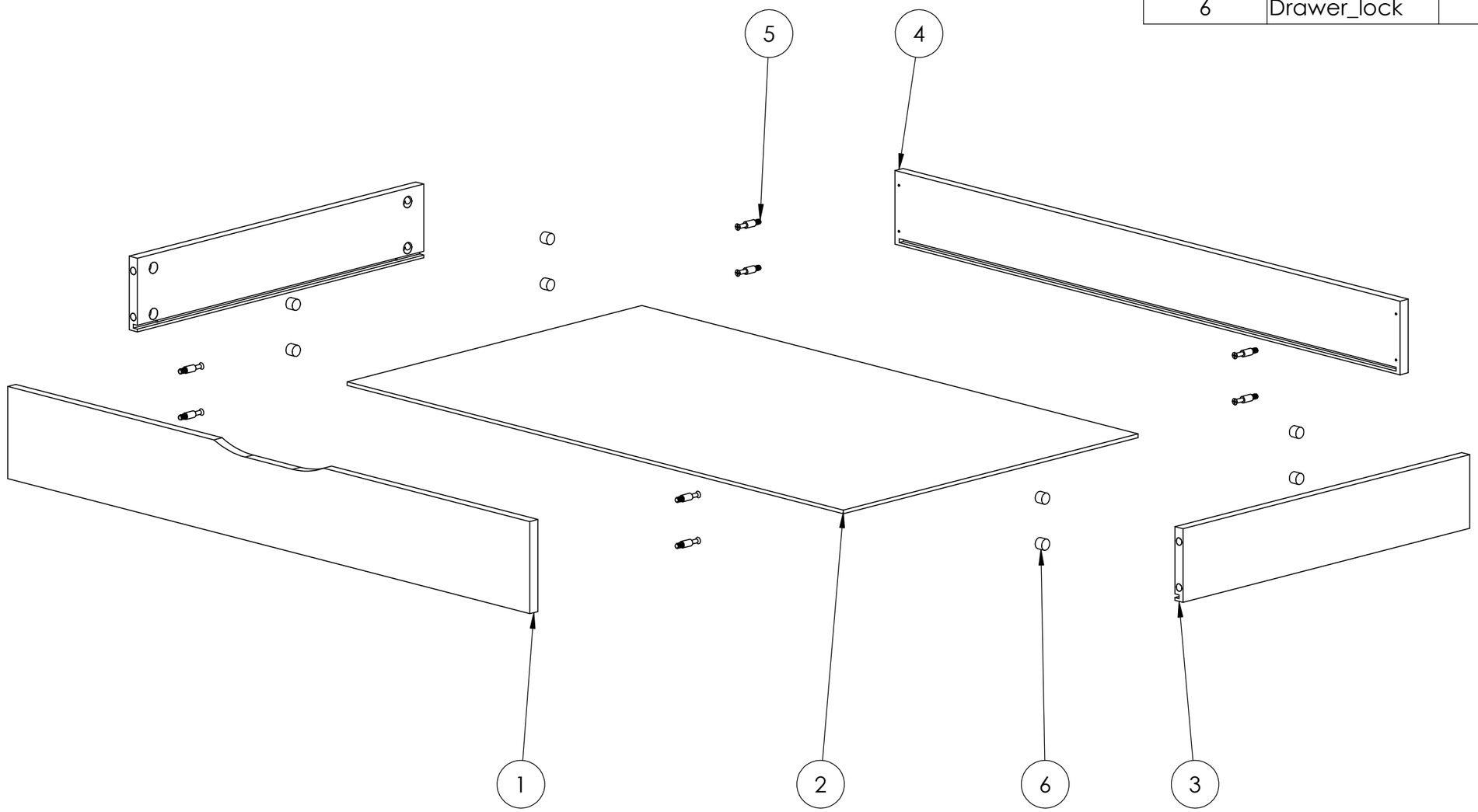




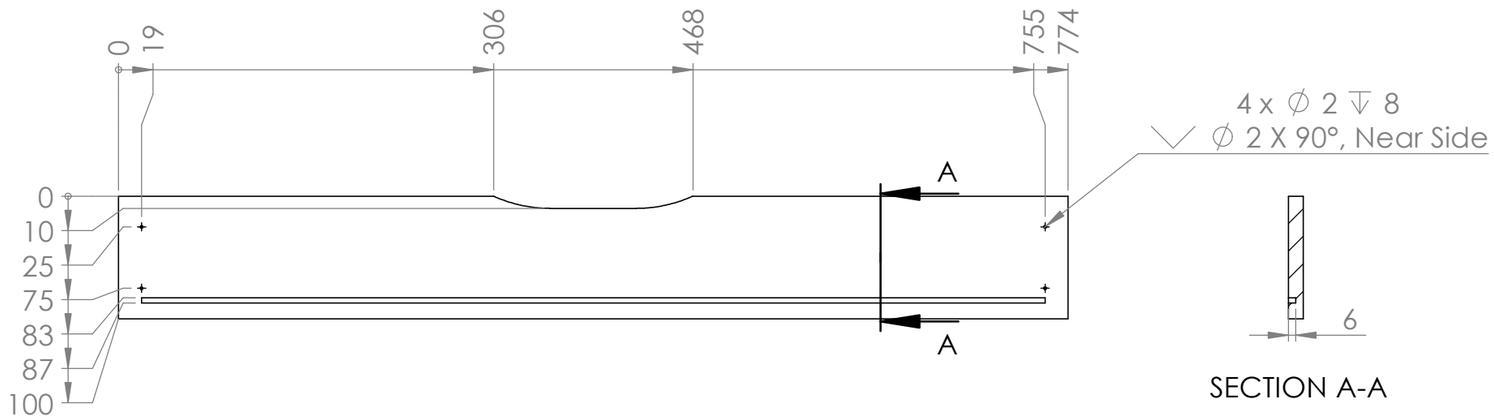


Part name: Leafy green tray	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: D. 4	Date: 25/05/23
Material: Terralene	Scale: 1:2

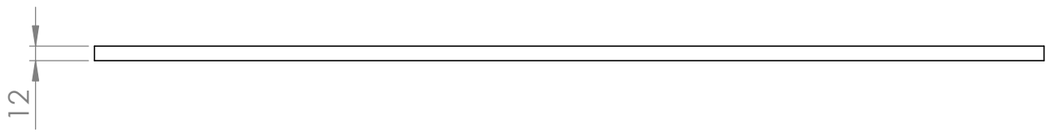
ITEM NO.	PART NUMBER	Material	Production	QTY.
1	Drawer_front	Okoume	CNC	1
2	Drawer_Bottom	Okoume	CNC	1
3	Drawer_sides	Okoume	CNC	2
4	Drawer_back	Okoume	CNC	1
5	Drawer_screw	-	-	8
6	Drawer_lock	-	-	8

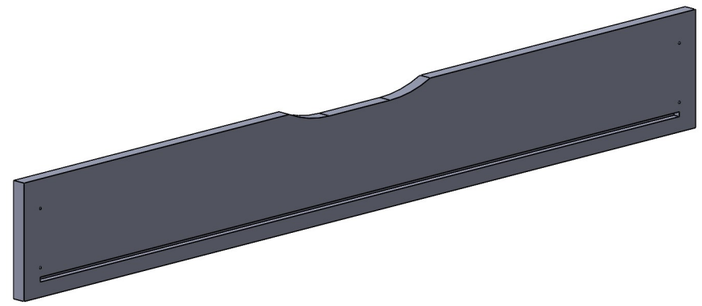


Exploaded view	Drawer
Vertigarden	Date: 25/05/23
Size: A3	Scale: 1:5

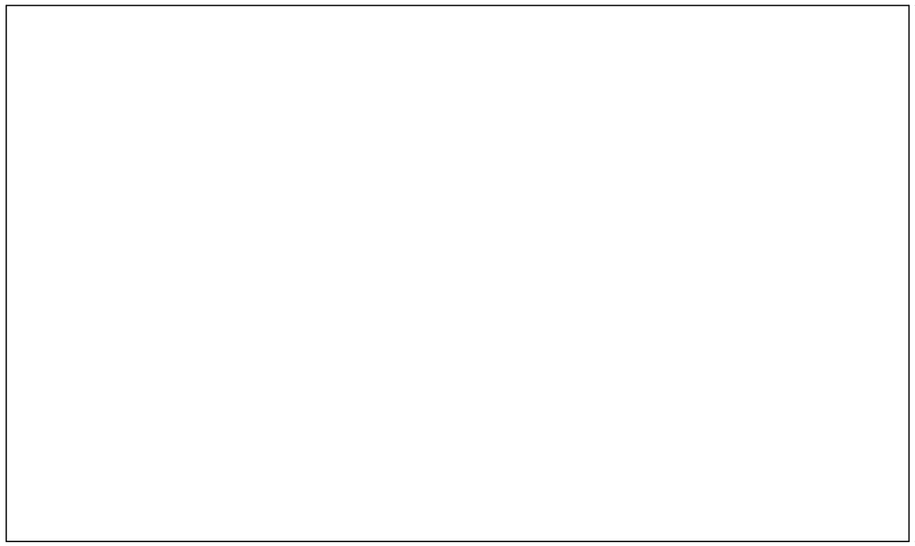


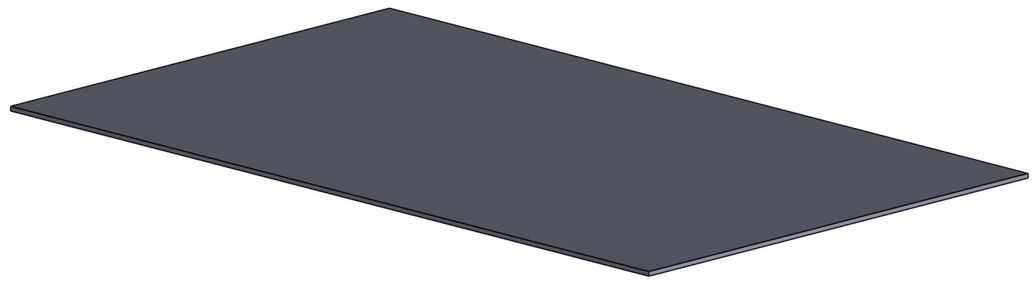
SECTION A-A



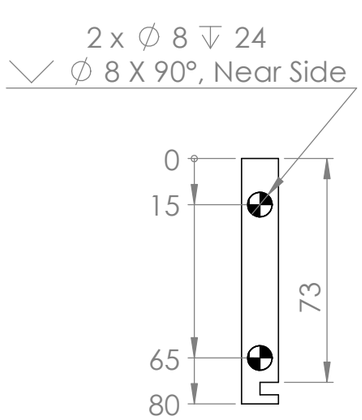


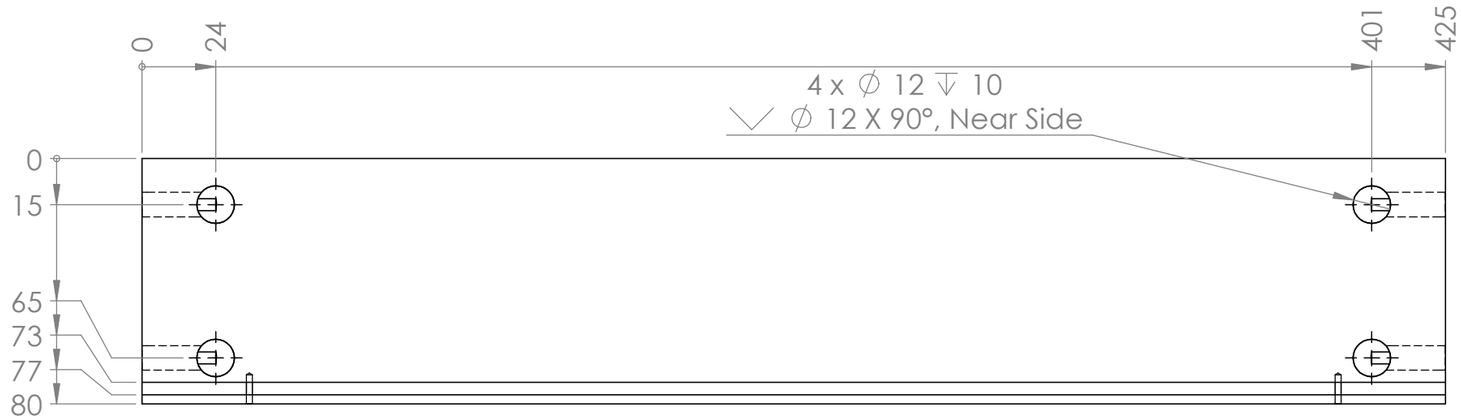
Part name: Drawer front	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: E.1	Date: 25/05/23
Material: Okoume	Scale: 1:5

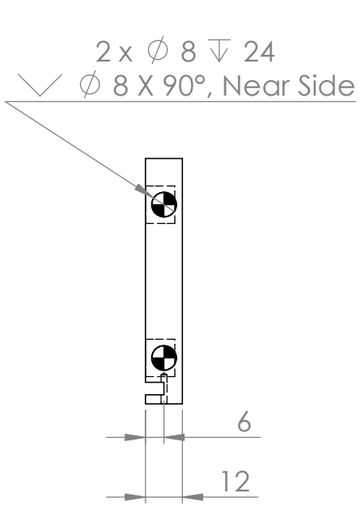


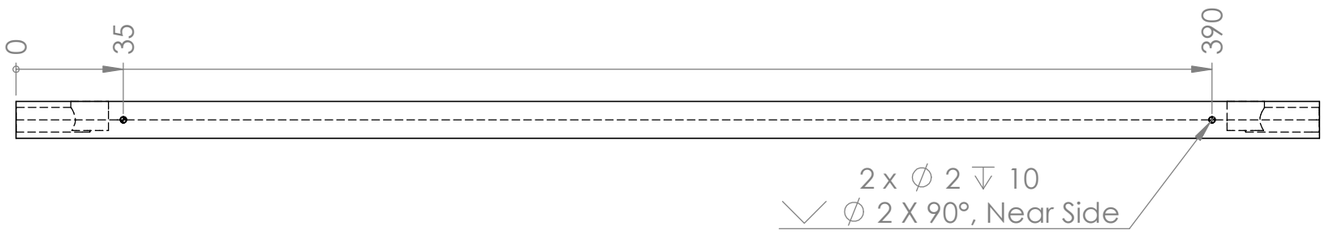


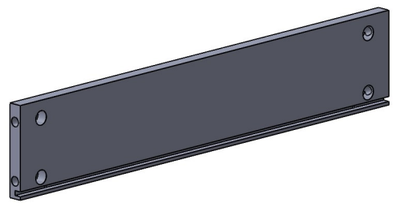
Part name: Drawer bottom	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: E. 2	Date: 25/05/23
Material: Oukome plywood	Scale: 1:5





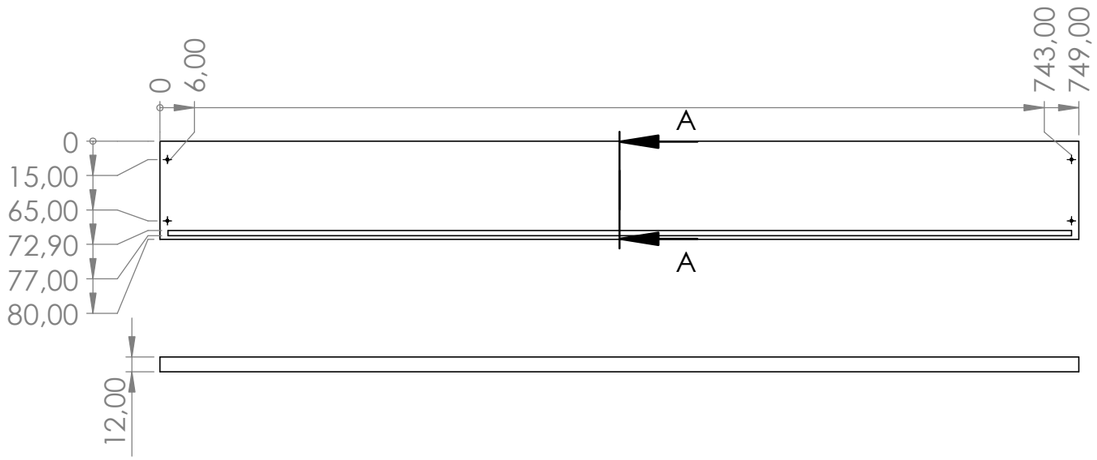


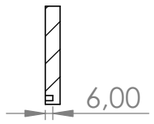




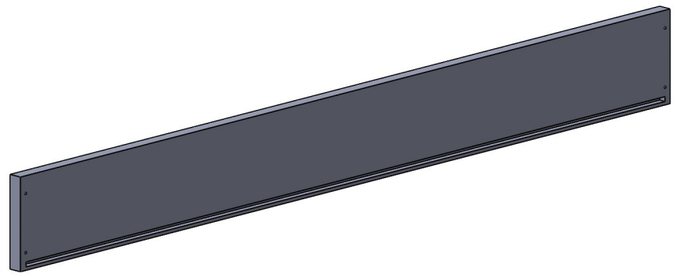
Scale 1:5

Part name: Drawer sides	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: E. 3	Date: 25/05/23
Material: Okoume	Scale: 1:2



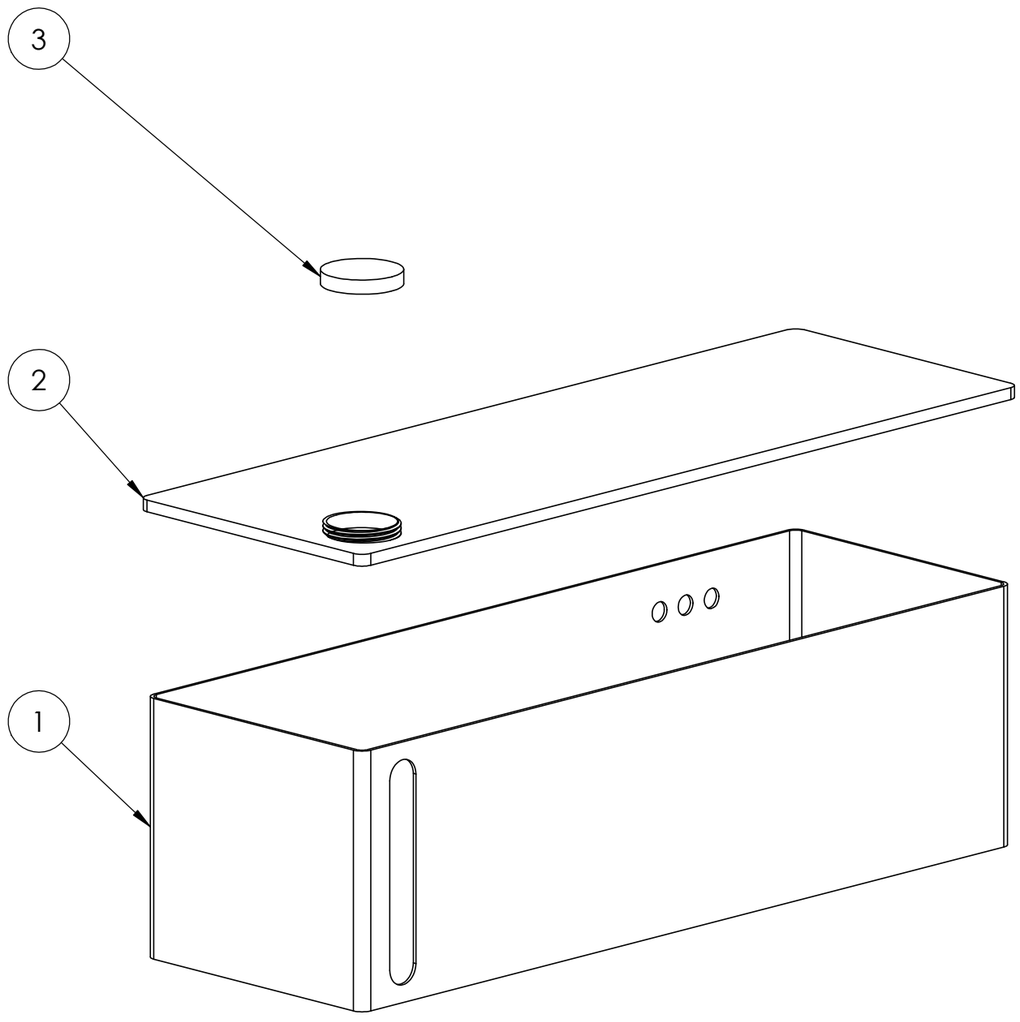


SECTION A-A

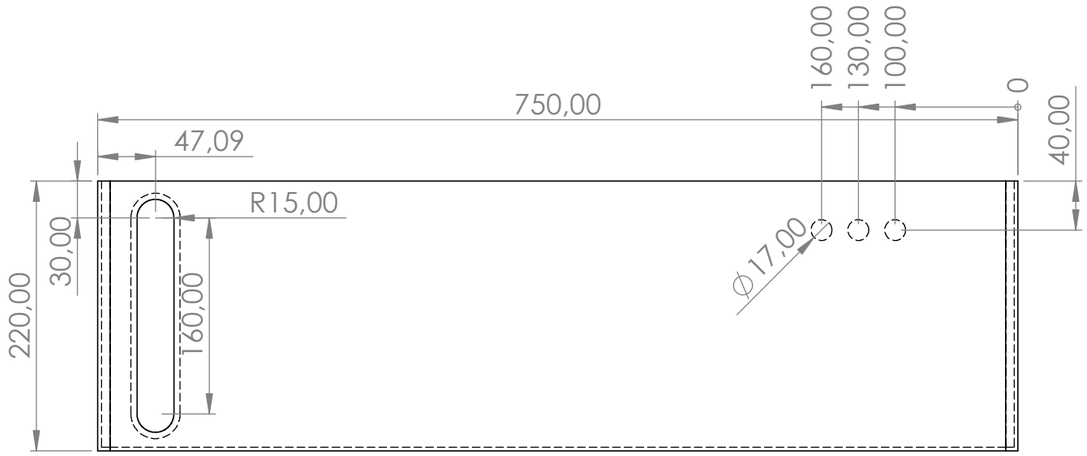


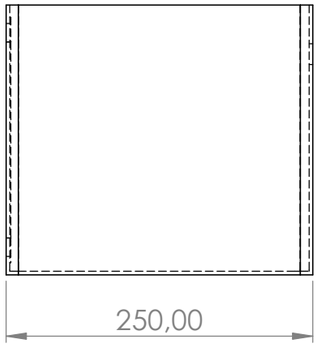
Part name: Drawer back	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: E. 4	Date: 25/05/23
Material: Oukome plywood	Scale: 1:5

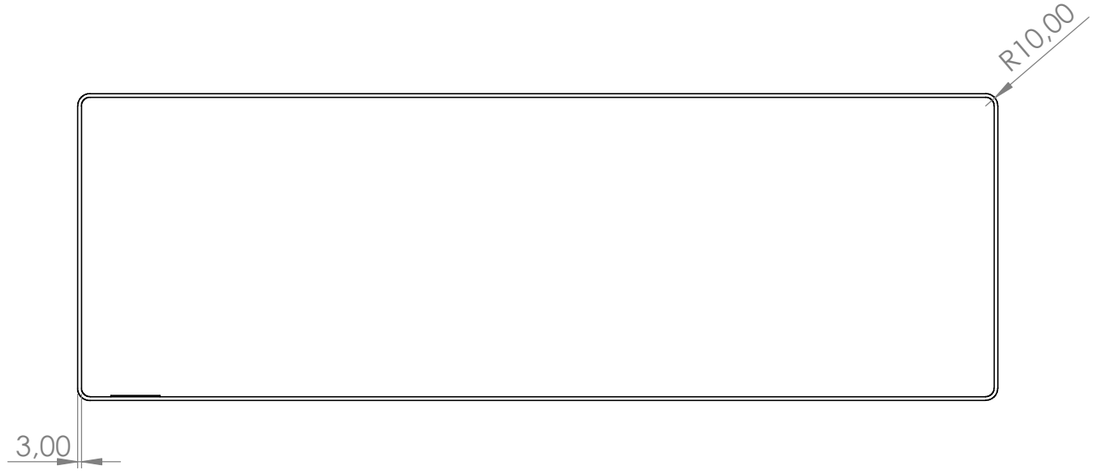
ITEM NO.	PART NUMBER	Material	Production	QTY.
1	WaterTank	Terralene	Thermoforming	1
2	Water_Tank_Lid	Terralene	Thermoforming	1
3	Lid	Terralene	Thermoforming	1

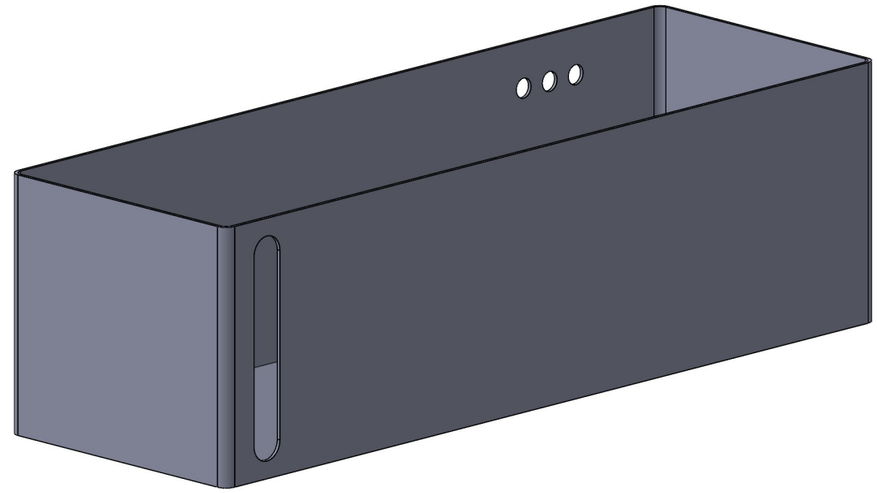


Exploaded view	Water tank
Vertigarden	Date: 25/05/23
Size: A3	Scale: 1:5

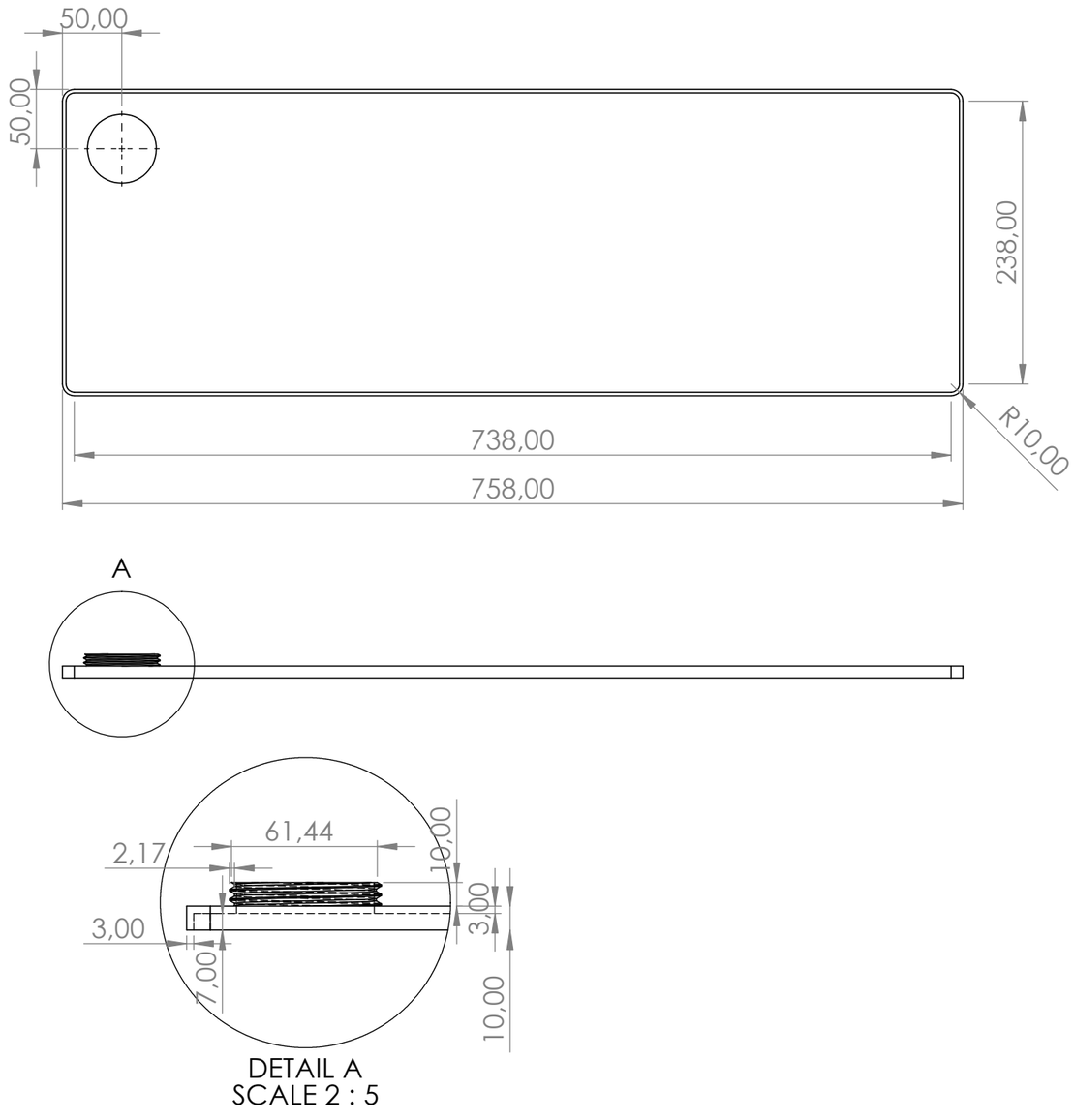






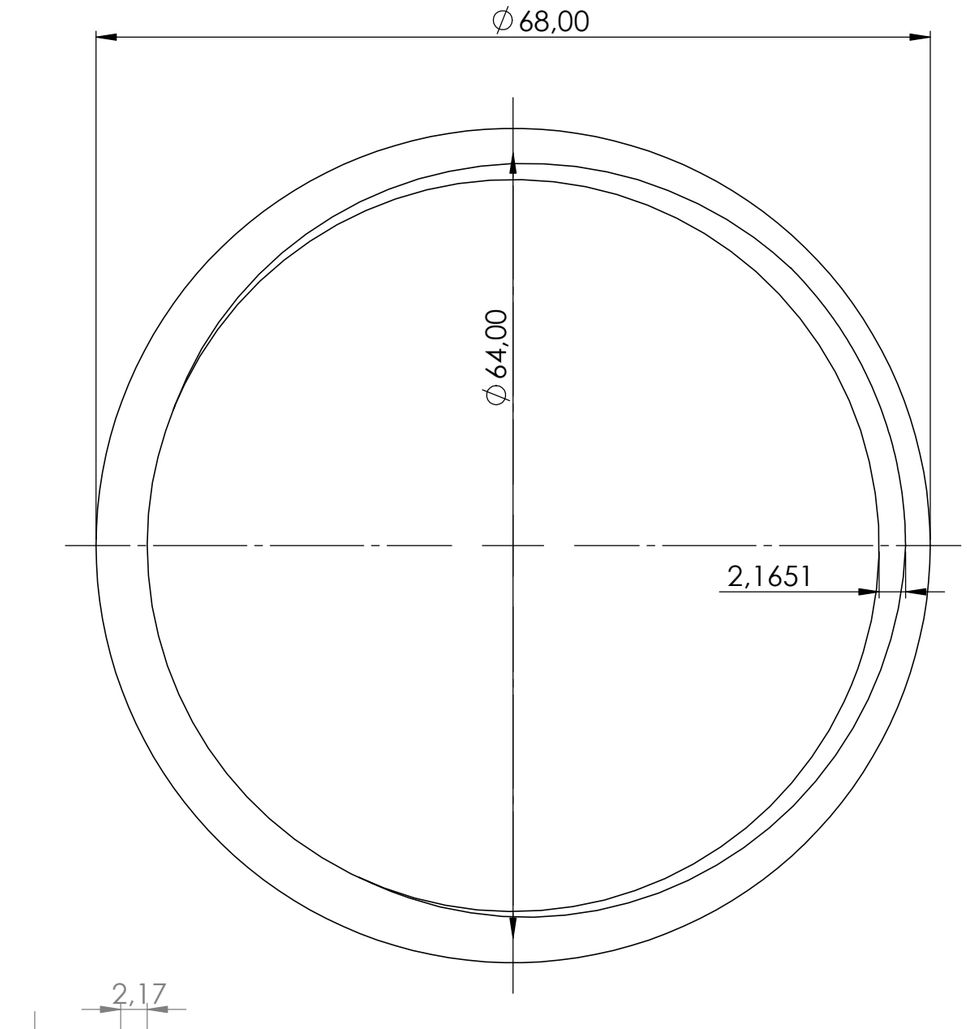


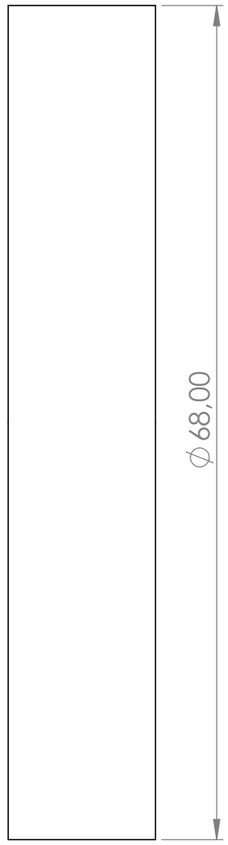
Part name: Water tank	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: F .1	Date: 25/05/23
Material: Terralene	Scale: 1:5

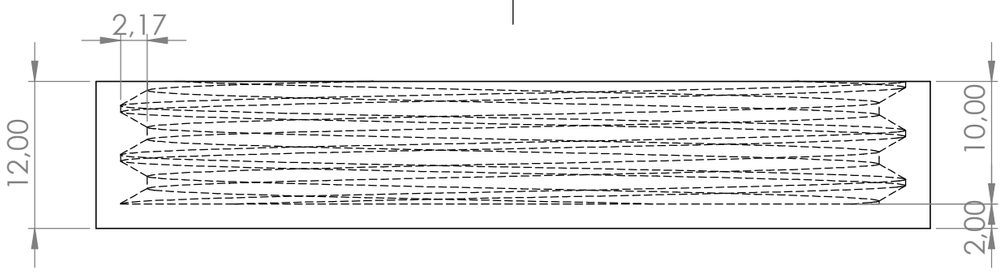


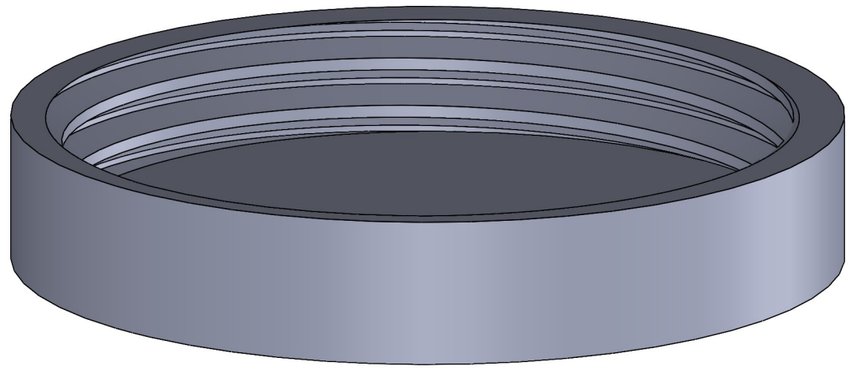
DETAIL A
SCALE 2 : 5

Part name: Water tank lid	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: F. 2	Date: 25/05/23
Material: Terralene	Scale: 1:5

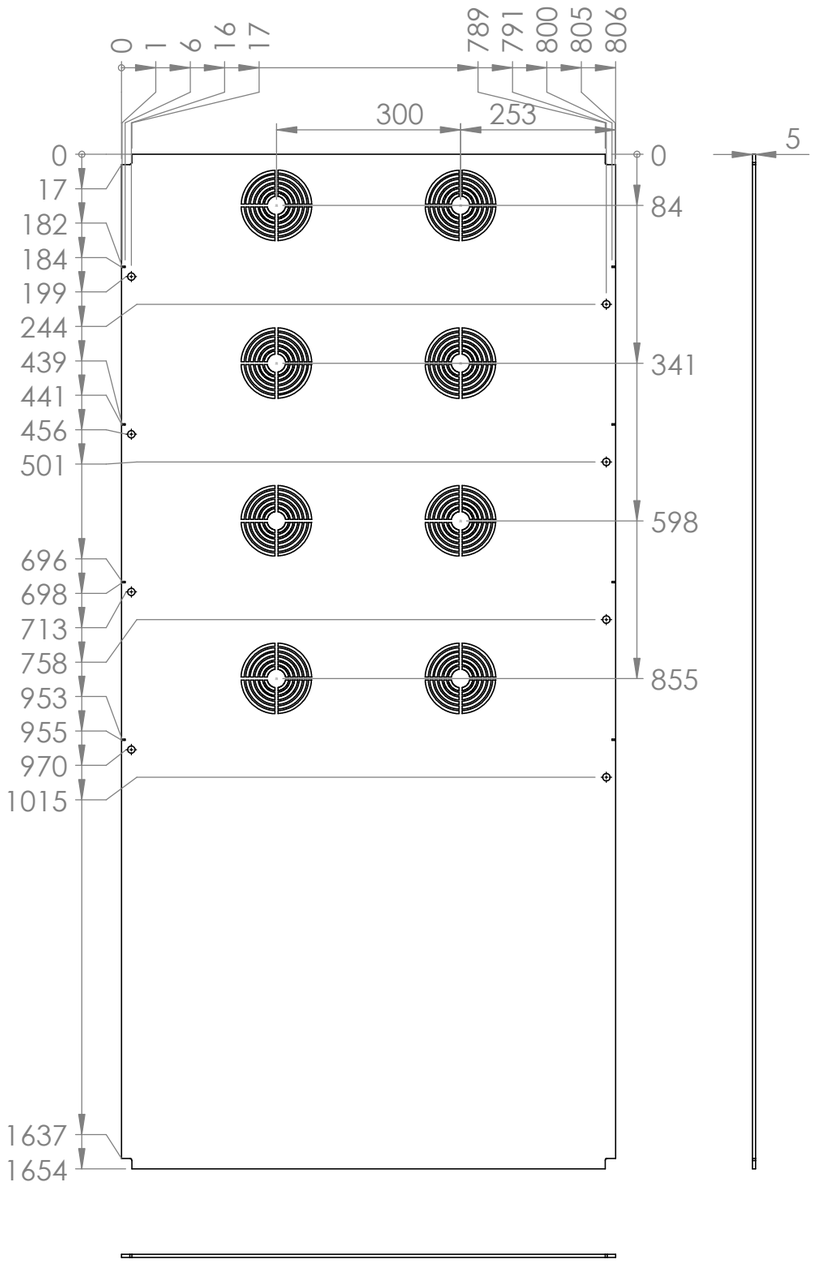


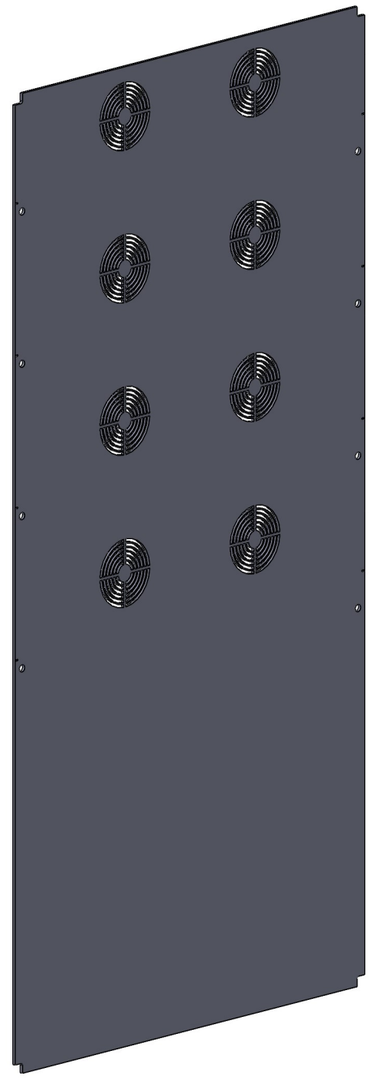




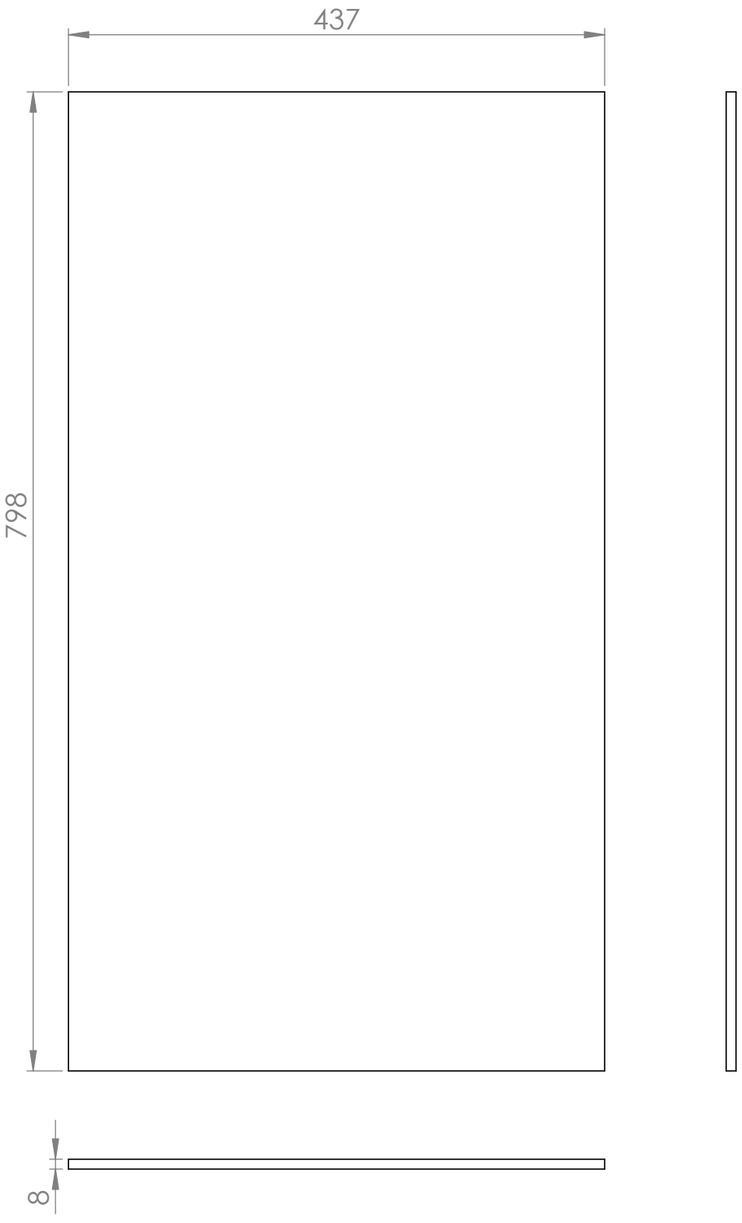


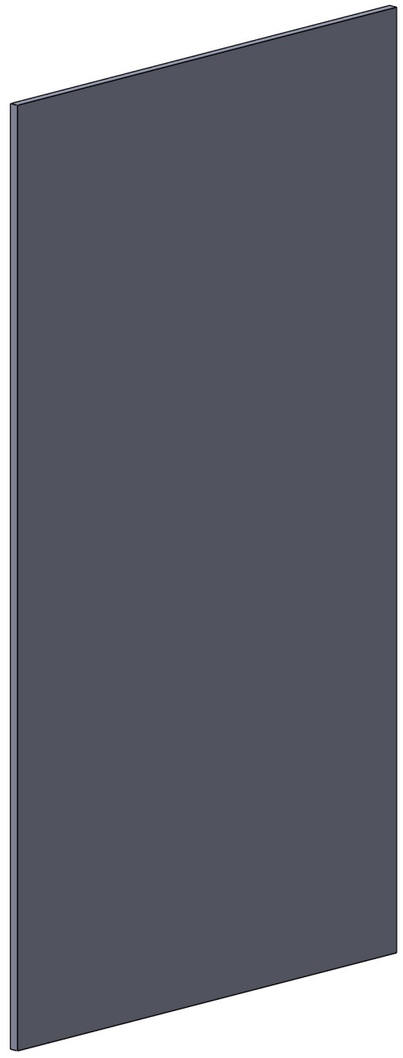
Part name: Lid	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: F. 3	Date: 25/05/23
Material: Terralene	Scale: 2:1



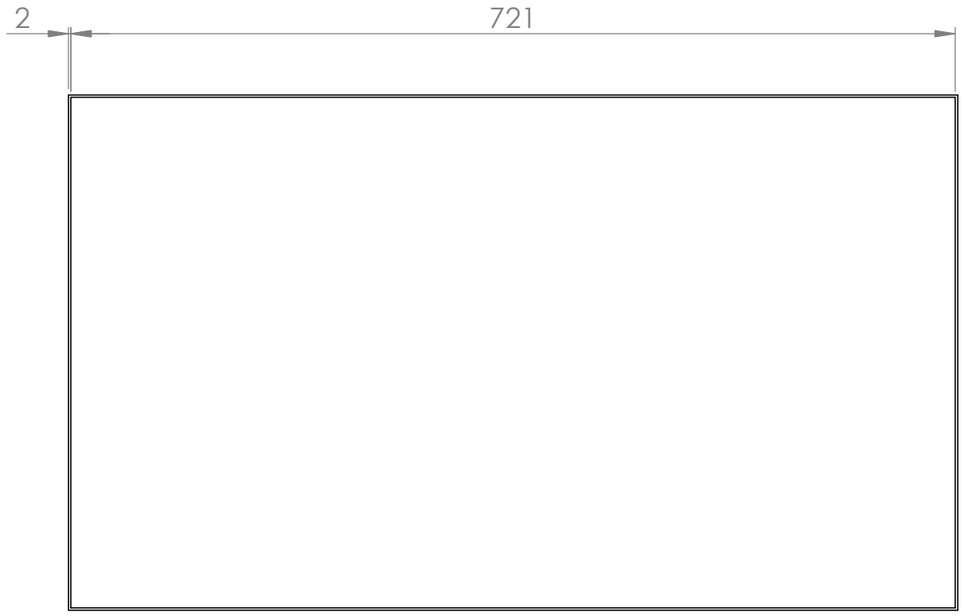


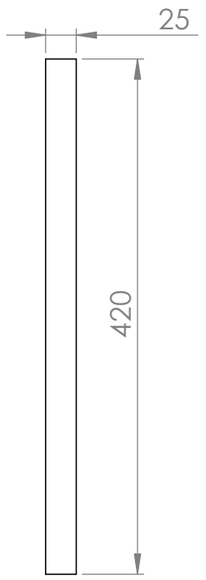
Part name: Second back panel	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: G .1	Date: 25/05/23
Material: Okoume	Scale: 1:10

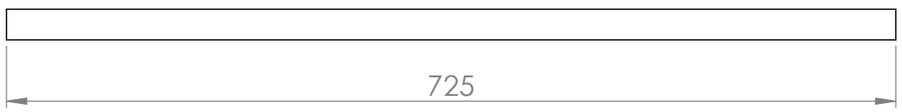


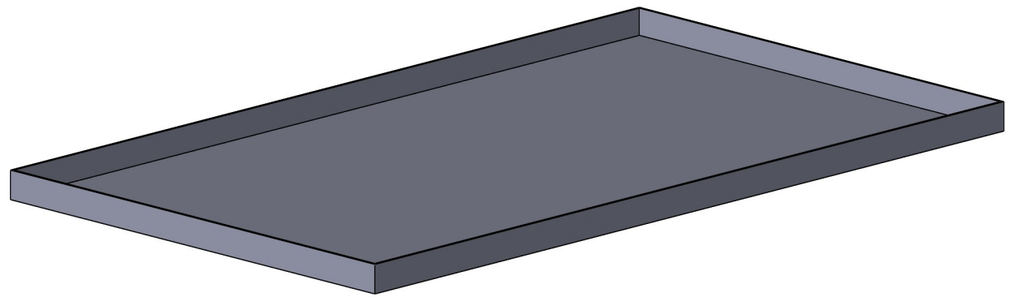


Part name: Wooden panel Top	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: G. 2	Date: 25/05/23
Material: Oukome plywood	Scale: 1:5

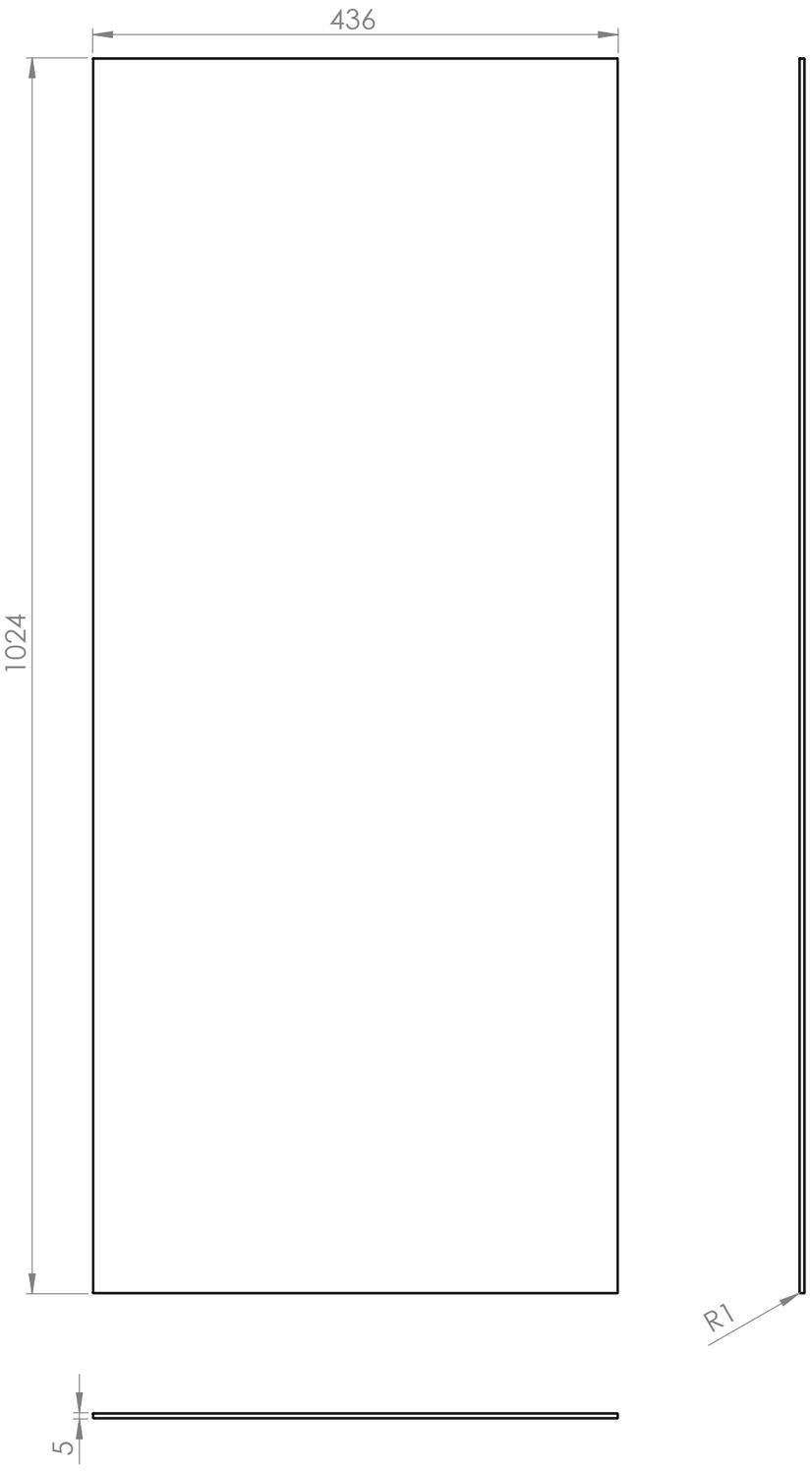




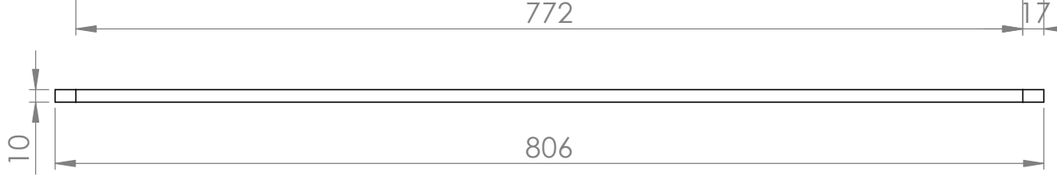


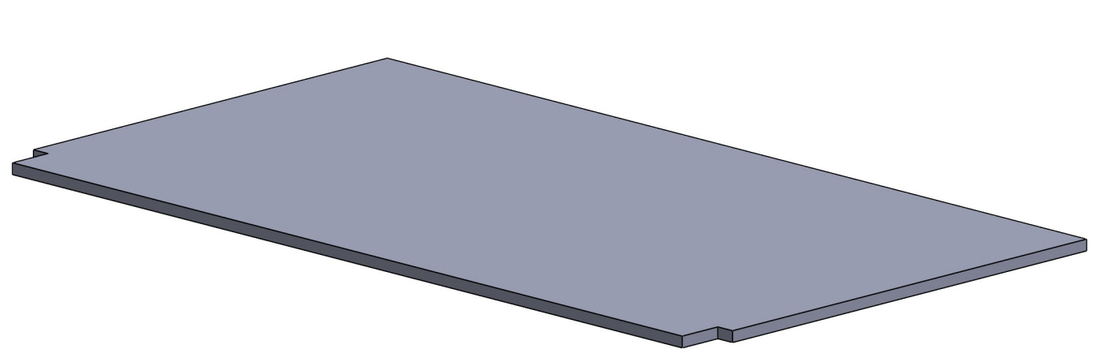


Part name: Germination tray	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: G. 3	Date: 25/05/23
Material: Terralene	Scale: 1:5

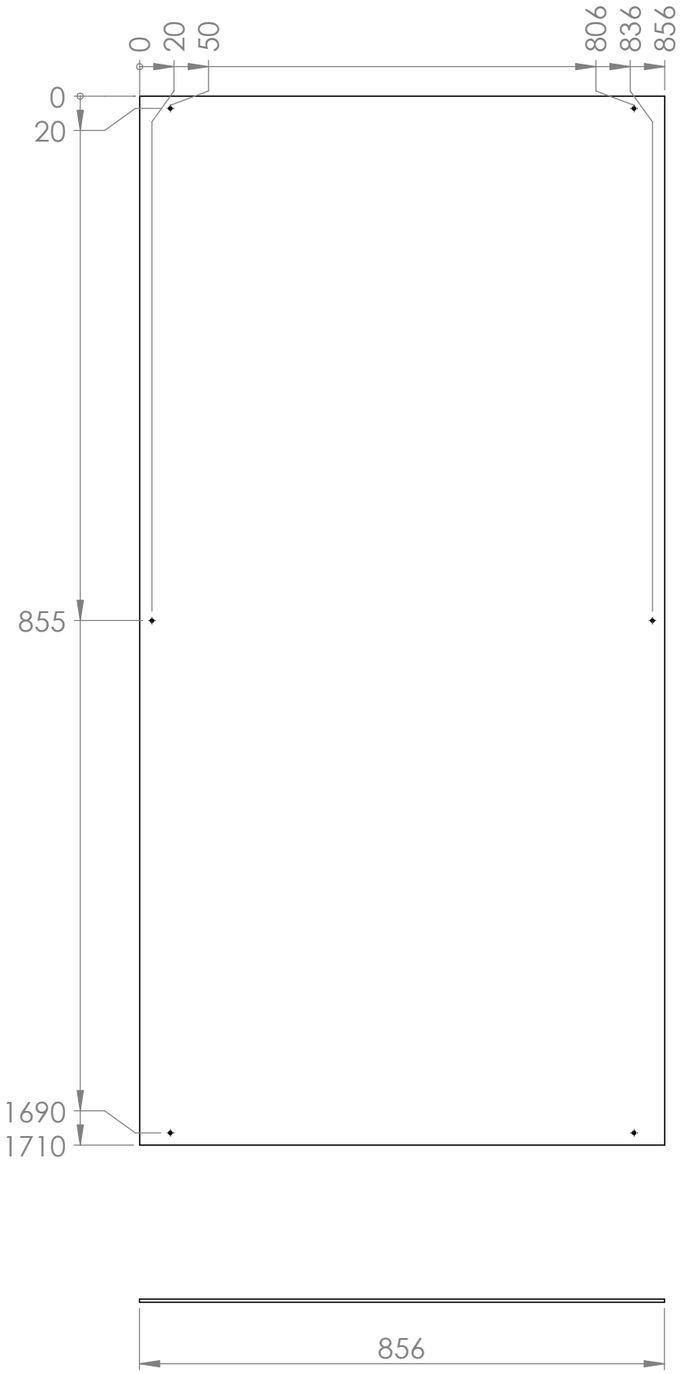


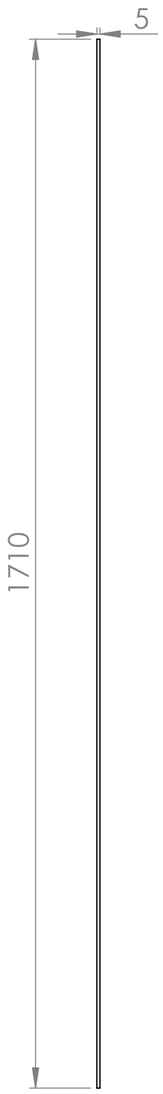
Part name: Glass side pannels	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: G. 4	Date: 25/05/23
Material: Glass	Scale: 1:5



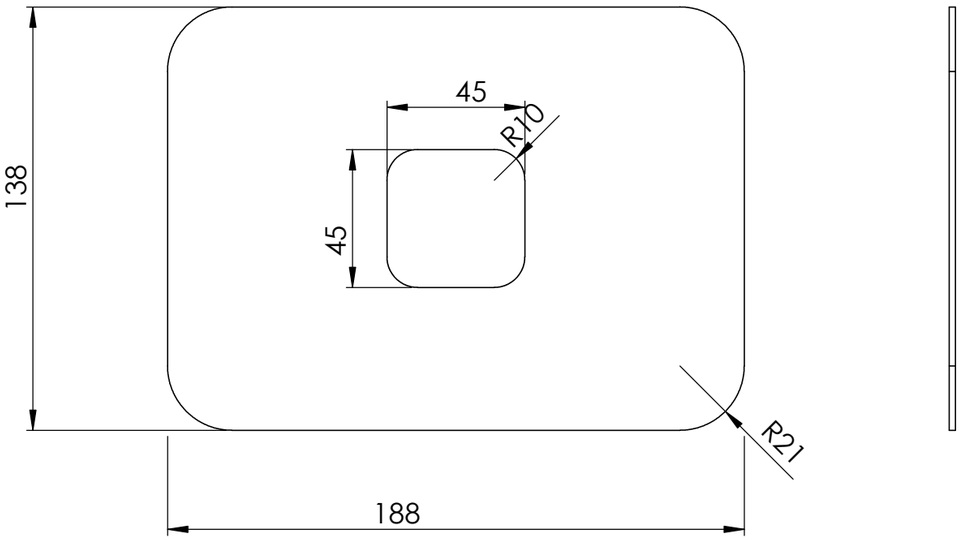


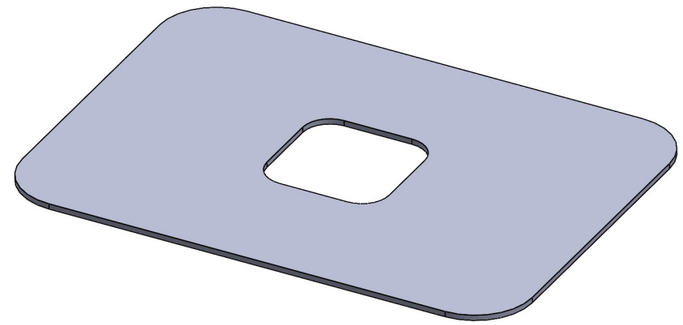
Part name: Wooden panel bottom	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: G. 5	Date: 25/05/23
Material: Oukome plywood	Scale: 1:5





Part name: Back panel	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: G. 6	Date: 25/05/23
Material: Oukome plywood	Scale: 1:10





Part name: Weigth Microgreens	Tolerances: Non- tolerance measures according to: DS/ISO 2768-Medium
Drawing number: G. 7	Date: 25/05/23
Material: Stainless steel	Scale: 1:2