ACETARIUM

PRODUCT REPORT

AALBORG UNIVERSITY / JUNE 2019
INDUSTRIAL DESIGN / MSc04 - ID4
SIDSEL KEIS FOMSGÅRD AND TOBIAS TOLLAK

GROW 4

ABSTRACT

Dette afgangsprojekt omhandler udviklingen af et produktforslag til at dyrke bladgrønt, som f.eks. spinat og bladbeder, i et lukket hydroponisk system uafhængig af vejr og temperatur.

I dag bliver det meste bladgrønt, der kan købes i danske butikker og bliver serveret på danske restauranter, dyrket under varmere himmelstrøg i eksempelvis Spanien og Holland. Der bliver det høstet, pakket og transporteret til Danmark hvor den almindelige dansker og restauranter kan købe salaten tidligst 7 dage efter den er høstet. Under transport tiden har salaten mistet det meste af sin næring og smag hvilket resulterer i en kedelig oplevelse når den serveres. Restauranterne bruger i dag et højt beløb på at få leveret bladgrønt fra Sydeuropa fordi det er en vigtig del af den visuelle præsentation af deres ala carte retter, men da kvaliteten er utilstrækkelig er det mange penge at bruge på et produkt de sjældent er tilfreds med. Et alternativ er at dyrke salaten selv, men med det danske klima bliver det sæsonbestemt hvis det er udendørs, ellers skal det gøres indenfor hvis man ønsker frisk salat året rundt.

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TITLE:	Acetarium
THEME:	Hydroponic system
PROJECT PERIOD:	01.02.2019 - 06.06.2019
PROJECT TEAM:	GROW 4 / MSc04 / ID4
SUPERVISOR:	Kaare Eriksen
CO-SUPERVISOR:	Poul Henrik Kyvsgaard Hansen
NO. OF PAGES:	24

The project is documented in a product report, a process report, a worksheet appendix and technical drawings. It is recommended to read them in the following order; product report first followed by process report together with worksheet appendix and lastly for measurements the technical drawings are viewed. This report should be viewed as a sales report with the purpose to present the product to potential customers. All the illustrations presented in the report is made by the team and therefore not referred to.

GROW 4

INTRODUCTION

This master thesis project is driven by an opportunity for challenging the supply chain of leafy greens and potential for making a difference for not only the restaurants but also the restaurants customers. Hydroponics is a rising trend both in industry and private homes. As it is just starting to trend, it is still a rarely new phenomenon for the ordinary person. In Denmark there is mainly one running growery where they are still experimenting with growing indoor in a hydroponic system, otherwise, it is mostly private persons who have a little grow system on the kitchen table. The hydroponic community has products, working principles and great potential but the existing products are either for industrial setups or hobby projects. By this, an opportunity is found for this project to improve or rethink the existing solutions by focussing on a solution for smaller businesses as restaurants.

Abstract	/	2
Reading guide	/	3
Introduction	/	4
The challenge	/	6
Acetarium	/	8
Acetarium in use	/	10
Materials and Dimensions	/	16
Components	/	18
Price and value	/	20

LOCAL FARMS ARE RISING

The awareness of using locally grown greens is raising, but with the Danish climate, the greens grown locally is very season dependent. It is only possible to grow salad outside in Denmark 4-5 months out of the year. The rest of the year you will need to settle for imported salads which is without taste, freshness and nutrients. They are not visually pleasing and the experience of eating it is unsatisfying at best.

HYDROPONIC FARMS IS THE FUTURE

At this time hydroponic farms are popping up all over the planet to produce locally grown greens for the surrounding areas. But to get a farm going a large investment is needed and expert knowledge is a necessity to get started. The products available for larger set-ups are not customized and the farmers need to set up the whole system by themselves with multiple different products. If you want to buy a “starting kit” the majority of products available are small scale hobby kits. There is a need on the market for industrialized professional equipment, easy to get started and an “all-in-one” solution.

The average fine dining restaurant is annually spending 208.000 DKK in delivery fee on acquiring imported greens. 52.000 DKK of these delivery fees are spent on acquiring leafy greens used for a pleasing presentation of courses. Local or in-house production of leafy greens will release this amount, so it can be spent on pleasing locally grown leafy greens instead.

ACETARIUM

Acetarium provides a closed environment for growing leafy greens at the restaurant. By placing it at the restaurant there will be no transportation, uncertainties of the quality of delivered greens or high delivery fees. One Acetarium can provide 4,5 kg of leafy greens every three weeks. It includes a watering system, LED grow light and a climate system which run automatically. As long as you fill up the water tank once a week, the system will take care of the rest. If you want to spread out the harvest to more times a week, and not only every three weeks, you can either buy four Acetariums and have one for each week and one back-up. Otherwise, you can prepare, as an example, one tower at a time over a period of three weeks, and thereby you will be able to harvest a little every day.

HOW TO USE
ACETARIUM

Acetarium is easy to manage when you first begin. The use of Acetarium is explained with illustrations in 20 easy steps to get started. An introductory course will be offered when you buy Acetarium to ensure all relevant employees are well informed about the correct use. The instructions presented is going through the seeding process, harvest process and how to clean the inside of Acetarium properly.

Place the dry coco core plug in the plug holder.

Water the plug until it expands to fill out the plug holder.

Place the seed inside the groove in the plug.

Slide the plug holder into the slot in the tower. It is now ready to insert into Acetarium.

Grip the edge of the lid to roll Acetarium out from under the table.

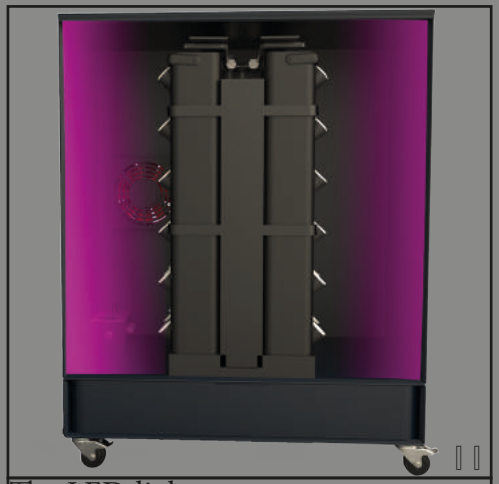
Use the same edge as a handle to open the lid.

When the lid is open the water system is turned upwards to make space for the tower insertion and block water.

Use the handle of the tower to slide the tower into the tower holder.

Turn the water system back down to open up the water flow again.

Press the start bottom on the junction box to turn on the system.

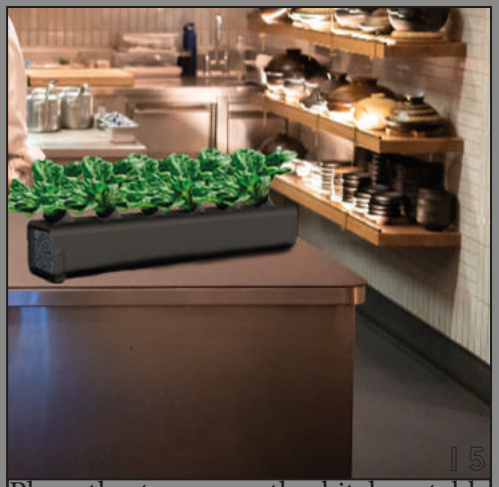


The LED light, water system, sensors and climate system is now turned on and operate automatically.

Close the lid and roll Acetarium back under the table.

After three weeks the leaves are ready for harvest. Acetarium is rolled out from under the table and opened.

Take up the tower with all the full-grown leaves.

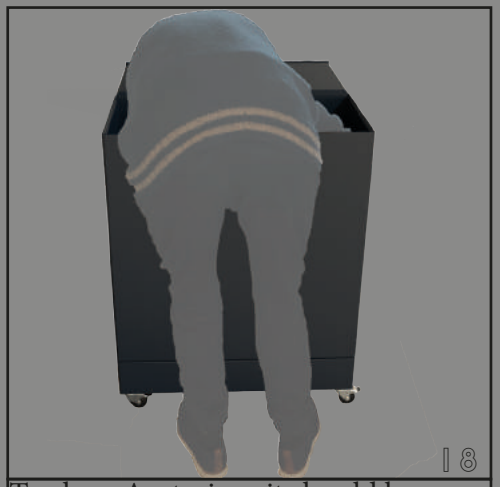


Place the tower on the kitchen table where it will be placed in an angle by using the handle as a holder.

Take the leaves and plugs out. It can either be used directly or stored in the cooling room.

17

Place new plugs and seeds in the plug holders and start over.



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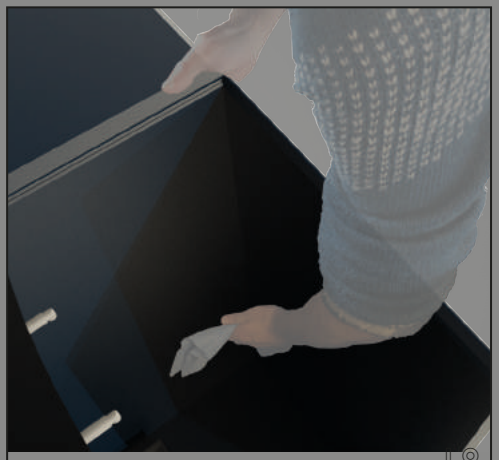
To clean Acetarium it should be empty and turned off. Bend over to reach the bottom.



19

Clean the inside of the box by using a cloth.

20

The towers have a size so it can go into an industrial dishwasher.

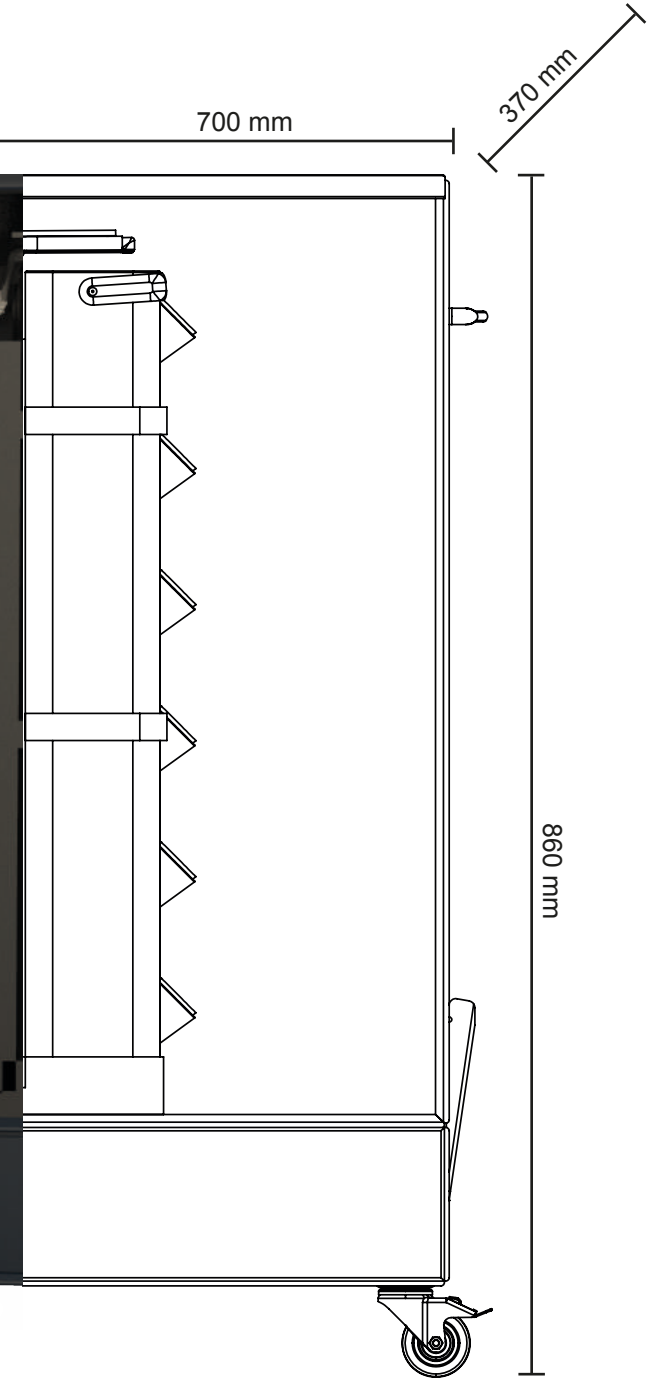
MATERIALS AND

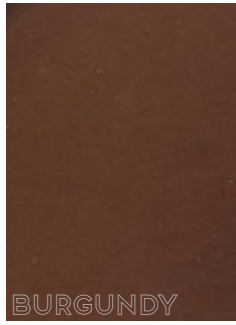
The box and wheel cart are produced of basilit processed pinewood plywood in 10mm, covered with linoleum laminate both on the inside and outside. This provides a water repellent environment for growing leafy greens.

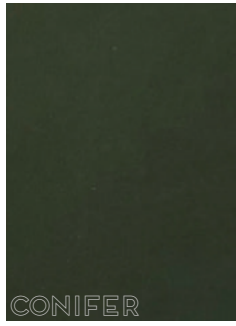
All inner parts such as the grow tower, tower holder, plug holder, water tray and the water tank is made from recycled polypropylene. Polypropylene is safe to use around food, it is resistant to bacteria and is maintenance-free.

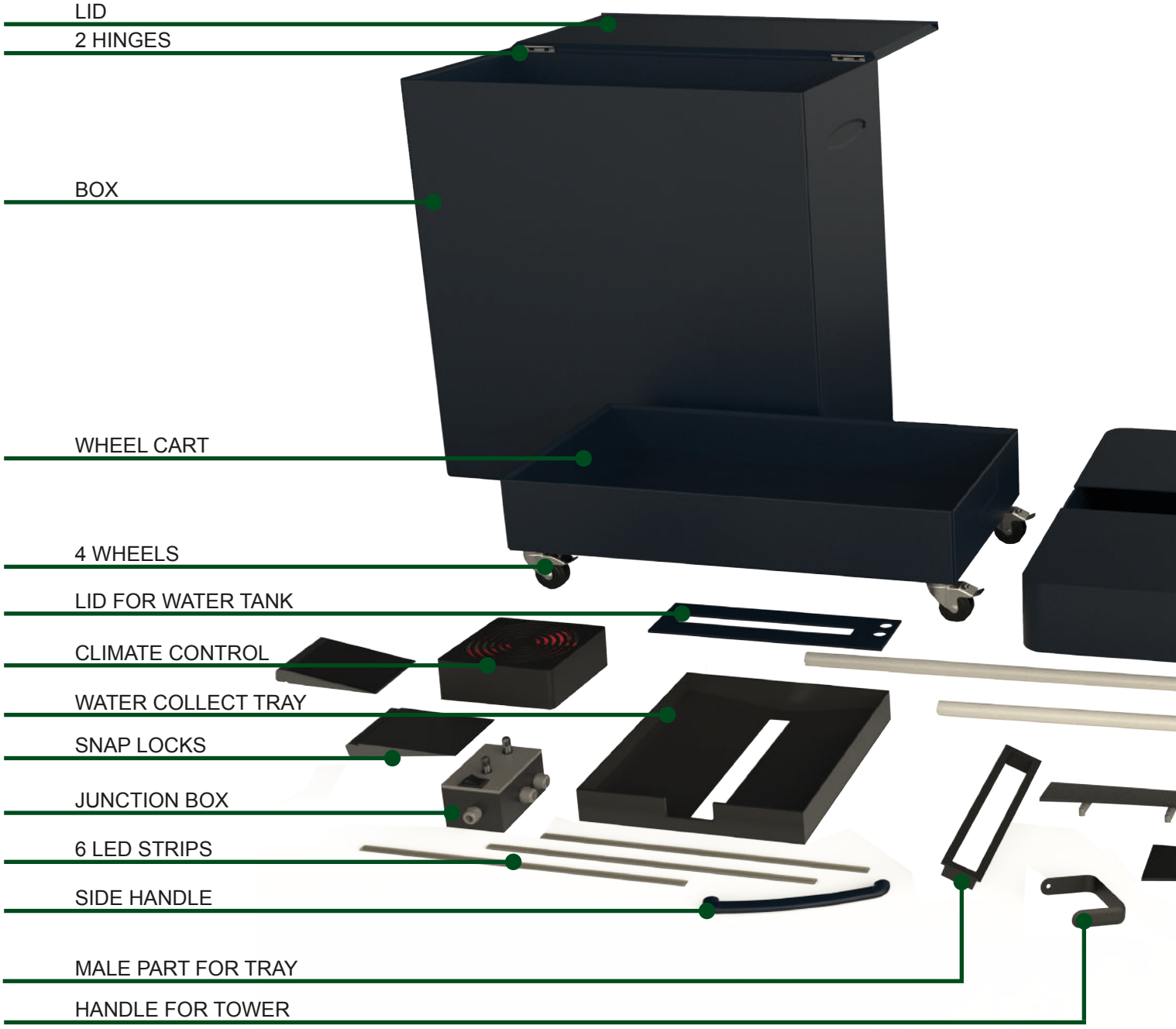
As standard, the linoleum laminate is the color smokey blue. It is also available in burgundy (dark red), pewter (dark gray) and conifer(dark green). Thereby if more than one Acetarium is needed, it will be possible to use the colors as a planning tool to tell the boxes apart when seeding and harvesting.

DIMENSIONS

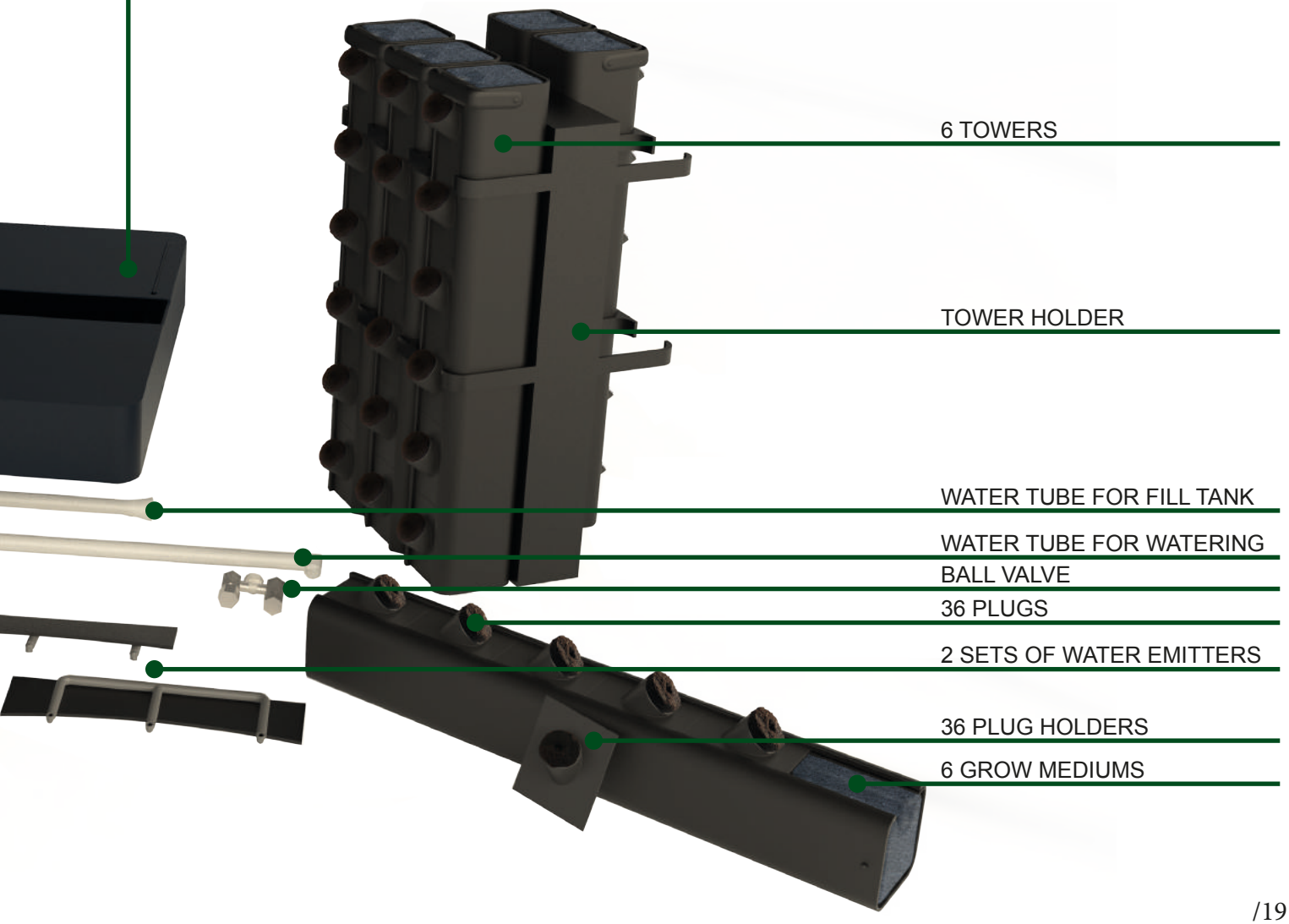







LID
2 HINGES
BOX
WHEEL CART
4 WHEELS
LID FOR WATER TANK
CLIMATE CONTROL
WATER COLLECT TRAY
SNAP LOCKS
JUNCTION BOX
6 LED STRIPS
SIDE HANDLE
MALE PART FOR TRAY
HANDLE FOR TOWER

COMPONENTS


WATER TANK
6 TOWERS
TOWER HOLDER
WATER TUBE FOR FILL TANK
WATER TUBE FOR WATERING
BALL VALVE
36 PLUGS
2 SETS OF WATER EMITTERS
36 PLUG HOLDERS
6 GROW MEDIUMS

VALUE

Acetarium provides restaurants the opportunity to use local produced leafy greens in courses on a daily basis. They get high quality, tasty, nutrient and fresh leafy greens which will be visually pleasing and satisfying to eat for the customers.

PRICE

The price for a full set of four Acetariums is 52.000 DKK, excluding nutrients, plugs and seeds. The price for one Acetarium is 13.000 DKK, but to eliminate the use of imported leafy greens it is recommended to buy the full set to have freshly grown leafy greens every day.

SERVICE

After purchasing the Acetarium package an additional service fee is paid every month. The service fee is on 1.500 DKK and includes an introduction course, annually service check and delivery of plugs, seeds and nutrients.

ACETARIUM

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PROCESS REPORT

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TITLE PAGE

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NO. OF PAGES:	99
WORKSHEETS:	68

READING GUIDE

The project is documented in four parts
Product report: *a presentation of the final product proposal.*
Process report: *a documentation of the process of the project.*
Worksheets: *an appendix of activities made during the project, which can be found on the attached USB.*
Technical Drawings: *a specification of the product proposal, which can be found on the attached USB.*

This is the process report which consists of four main phases: Discover, Define, Develop and Deliver. The purpose of the process report is to guide the reader through the project to show what thoughts, insights and arguments have resulted in the product proposal.

REFERENCES:

Throughout the report, only the references used directly in the text are referred to and can be found in the reference list. All other references are to be found in the individual worksheets. For references used in this report, the Harvard method is used and shown as; (Author, year).
Worksheets are referred to in the text by number as [WS#] and illustrations are referred to as (Ill. #)

WORD EXPLANATION

Germination:	*Have the seeds in a horisontal position until the roots are fastened*
Microgreens:	*Small seedlings which are harvested after 7-10 days*
Leafy greens:	*Larger leafy salads but not head salads*
Grow medium:	*Supporting the roots when they grow*
Plug:	*Where the seed is placed to be kept wet*
Condi buckets:	*Plastic bucket used for storing*

GROW 4

ABSTRACT

Dette afgangsprojekt omhandler udviklingen af et produktforslag til at dyrke bladgrønt, som f.eks. spinat og bladbeder, i et lukket hydroponisk system uafhængig af vejr og temperatur.

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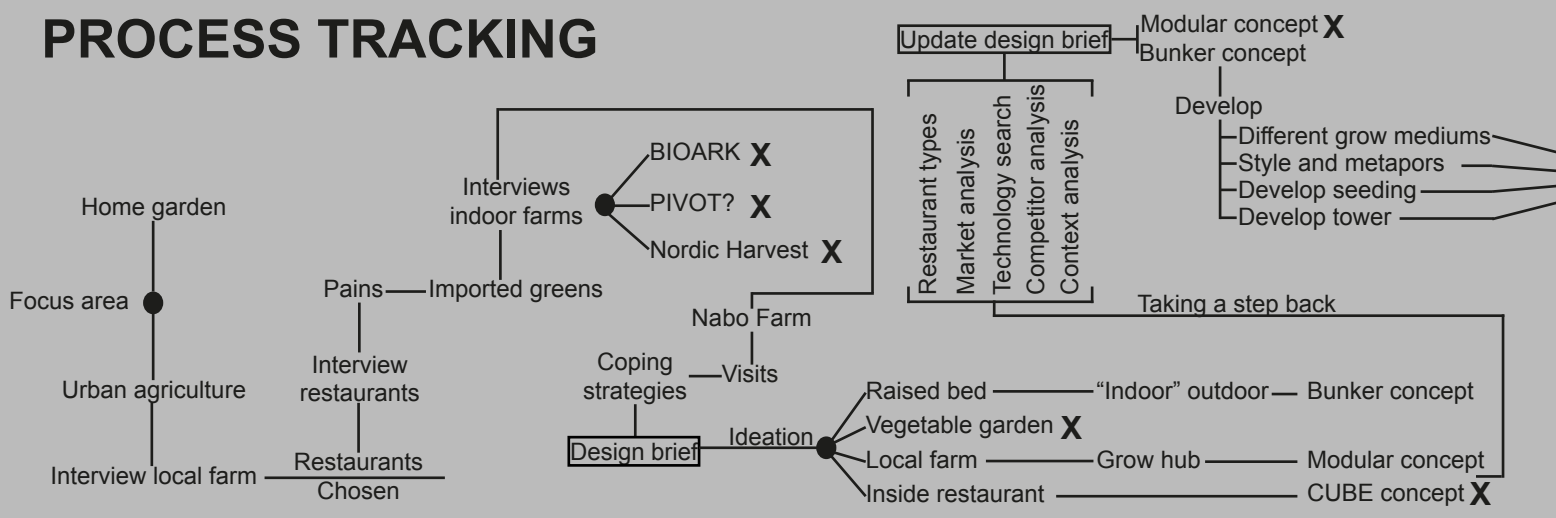
PROCESS TRACKING



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A special thank you to Jonna Hvas, Fladbro Kro for valuable insights, expert knowledge, test in context and feedback sessions.
For sharing helpful knowledge and experience within the field, a big thank you goes to:
Jens Juul Krogshede, Nabo Farm
Anders Ostenfeld Riemann, Nordic Harvest
Mikkel Stensgaard, BIOARK

INTRODUCTION

This master thesis project is driven by an opportunity for challenging the supply chain of leafy greens and potential for making a difference for not only the restaurants but also the restaurants customers. Hydroponics is a rising trend both in industry and private homes. As it is just starting to trend, it is still a rarely new phenomenon for the ordinary person. In Denmark there is mainly one running growery where they are still experimenting with growing indoor in a hydroponic system, otherwise, it is mostly private persons who have a little grow system on the kitchen table. The hydroponic community has products, working principles and great potential but the existing products are either for industrial setups or hobby projects. By this, an opportunity is found for this project to improve or rethink the existing solutions by focussing on a solution for smaller businesses as restaurants.

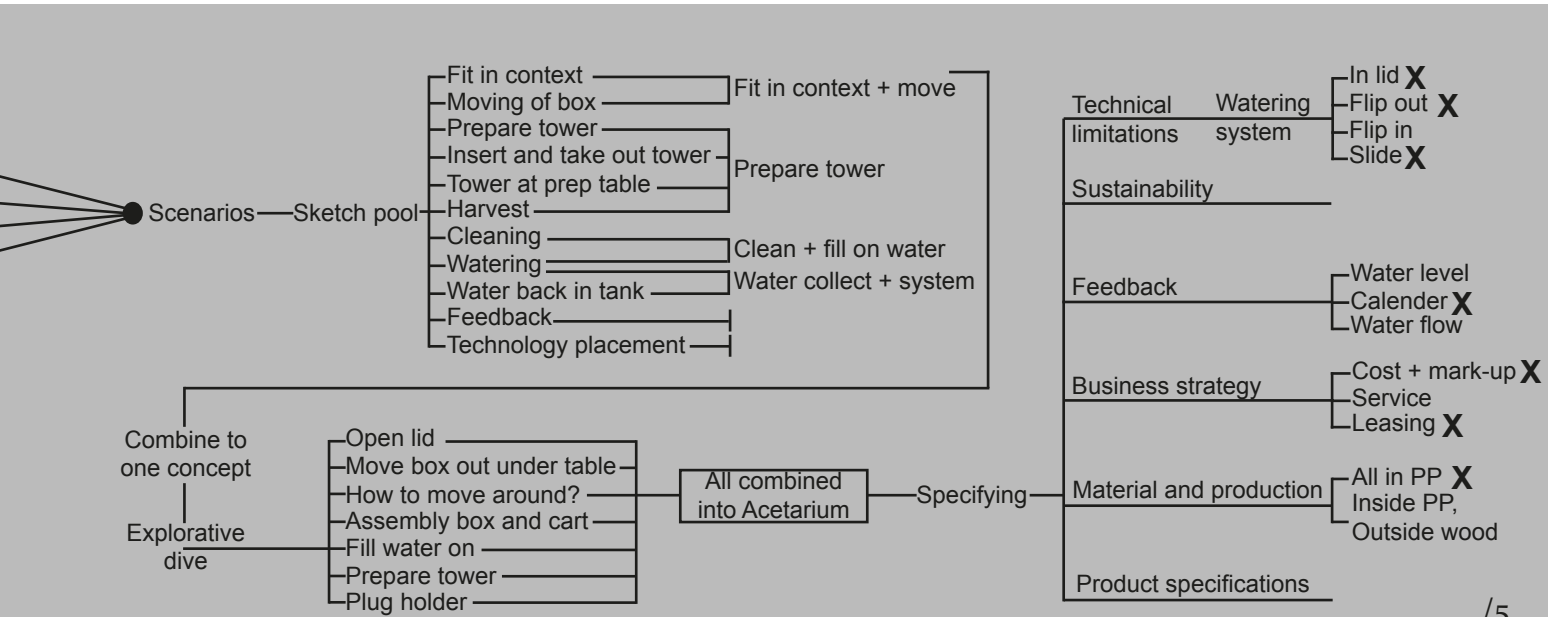


TABLE OF CONTENT

ALIGNMENT

TITLE PAGE 3
ABSTRACT 4
ACKNOWLEDGMENT 4
INTRODUCTION 5
PROCESS TRACKING 5
THEORETICAL FOUNDATION 8

DISCOVER

HOW DID WE GET HERE? 12
RESTAURANTS AND ECOLOGY 14
INTERVIEWS WITH RESTAURANTS 16
INTERVIEWS WITH INDOOR FARMS 18
IMPORTED GREENS 21
VISIT FLADBRO KRO 22
VISIT NABO FARM 24
COPING STRATEGIES 26
GAP ANALYSIS 27

DEFINE

UNDERSTANDING THE PROBLEM 30
DESIGN BRIEF 31

DEVELOP

INITIAL IDEATION 34
THREE CONCEPTS 36
TESTING AND FEEDBACK 37

DISCOVER AND DEFINE 2.0

DEFINING RESTAURANTS 40
MARKET AND ECONOMY 42
COMPETITOR ANALYSIS 42
HYDROPONIC TECHNOLOGY ANALYSIS 44
CONTEXT 46
UPDATES TO DESIGN BRIEF 47

DEVELOP 2.0

EVALUATE CONCEPTS 50
MOCK-UP AND TESTING 52
BOARDS, METHAPHORS AND FEELINGS 54
DEVELOP THE SEEDING PROCESS 56
DEVELOP THE TOWER 58
USER SCENARIO FOR SKETCHING 60
TJALVE SYSTEMATIC SKETCHING 61
SKETCH POOL ON PARAMETERS 62
SKETCHING ON SUBCATEGORIES 64
COMBINE TO CONCEPT 66
EXPLORATIVE DIVE 68
FROM CONCEPT TO ACETARIUM 80

DELIVER

KNOWING THE TECHNICAL LIMITATIONS 84
FEEDBACK SYSTEM 86
SUSTAINABILITY CONSIDERATIONS 87
ACETARIUM SPECIFICATIONS 88
MATERIALS AND PRODUCTION 90
BUSINESS STRATEGY 92

EVALUATION ON DEMANDS 96
CONCLUSION 97
REFLECTION 98
REFERENCE LIST 99
ILLUSTRATION LIST 99

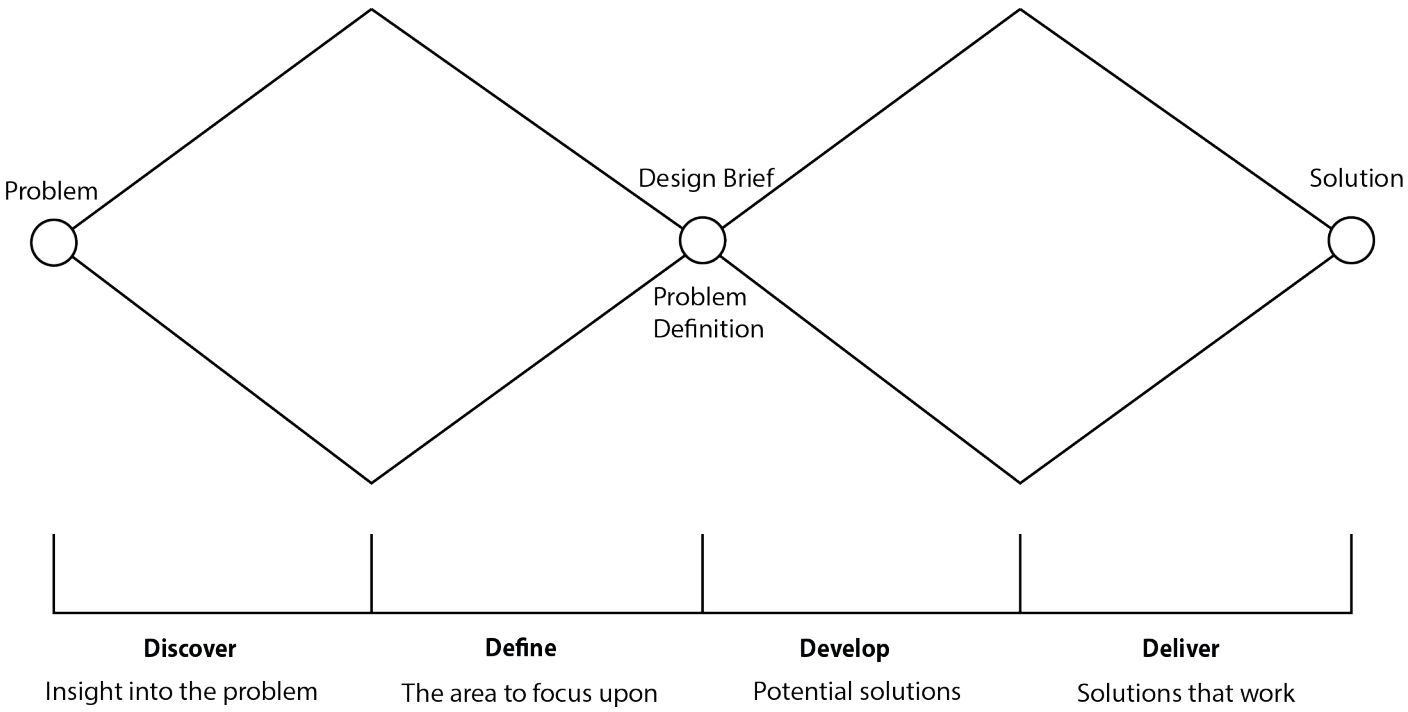
THEORETICAL FOUNDATION

PRAGMATIC APPROACH

In this master thesis project the pragmatic approach will be used to understand how the reality around the problem and the product proposal is. In practice, it is wished to talk with experts, potential users, potential stakeholders and test the hypothesis formed throughout the design process.

DOUBLE DIAMOND

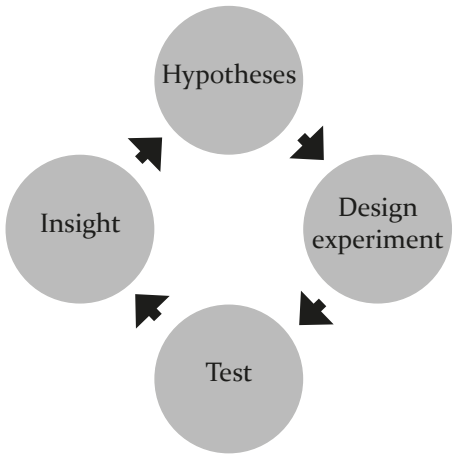
The double diamond model will be used as the main process method to steer the project. The model is divided into four phases which will be moved in between in an iterative process. This model will also structure the main deadlines for the project. Using The Double Diamond model, the project will in each phase diverge before converging into a more specific hypothesis, concept, market, etc.[Designcouncil.org.uk]



Ill. 1 - Double Diamond model

DATA COLLECTION PROCESS - HETI

The HETI model by Dorf and Blank [Blank & Dorf, 2012] will be used for data collection.
This model will also be the foundation of the worksheets.



Ill. 2 - The HETI model

The process consists of four steps in a loop:

1. Write down assumptions and hypotheses.
2. Create and design experiments to validate.
3. Test or perform experiments and collect data.
4. Analyze and reflect on gained insights.

In practice, the HETI model is an iterative process just like the design process. Together with The Double Diamond model, chosen to structure the process, this method will be used as the main structure of the thesis.
New insights create a path to new discoveries in a never-ending cycle.

In this master thesis, this model will be used in the design phase as a tool to keep creating new assumptions, and with these assumptions use experiments to validate or invalidate the assumption. Perform the experiment in the right context with users, mock-ups, sketches, renderings, interview or papers and lastly analyze and reflect upon the key insights from the experiment. This will be done throughout the thesis and be documented in both worksheets and this report.

TIME USAGE IN THE PROJECT

The time used from the master thesis kickoff in February until the hand in on the 6th of June is presented. The illustration (ill. 3) shows the amount of time spend on the different phases of The Double Diamond model. Even though the timeline is linear the design process of the thesis has been iterative where the team has jumped back and forth between the phases, depending on the different obstacles met during the process.

Ill. 3 - Linear overview of time spend in each phase

Ill. 4 - Discover introduction

DISCOVER

In the discover phase the project direction was formed from initial thoughts, interviews with possible users, experts within the field and visits at both experts and users. The team succeeded in finding a challenge in the supply chain delivery of greens for restaurants, which could be possibly solved by a industrial design product.

Chapters

- How did we get here?
- Restaurants and ecology
- Interviews with restaurants
- Interviews with indoor farms
- Imported greens
- Visit Fladbro Kro
- Visit Nabo Farm
- Coping Strategies
- Gap Analysis

HOW DID WE GET HERE?

INITIAL IDEA FOR AN INDOOR APARTMENT GARDEN

The first week of the project was spent on defining a focus area. In the project description hand-in, the chosen focus was an indoor apartment garden for people in major cities.

The phenomenon of indoor gardens is a rising trend in todays society. A rise in population in major cities, combined with less outdoor space, is the main factor because people do not have the same garden space today as former generations.
Caleb Harper describes a shift in agriculture from the traditional to a more technological as a result of the rise in population and lack of space[Harper, C., Siller, M. 2015]. In todays lifestyle, where more people wants to take environmental and ecological responsibility, the possibility for growing your own pollution-free vegetables "back to basics" is wanted. This results in a rising need for having individual gardens, which makes it possible to grow ecological vegetables in a clean and controlled environment indoors.
The trend is especially shown in newly established urban gardening spaces in larger cities, where apartment owners or renters can be a part of an urban society, where different people can join and share the experience of growing and harvesting their own vegetables. The pain with these urban gardens is that they are placed in public, and therefore accessible for everyone, can be exposed to vandalism and is season dependent.
When developing a closed and controlled environment for growing vegetables in personal homes there is an opportunity to scale the product into being sold B2B aimed at restaurants who want to brand themselves on growing their own vegetables. This trend can be seen at big restaurants such as "Kong Hans" and "NOMA".
Right now the restaurants who can afford it have gardens outside the cities to grow their own vegetables. With a product for growing local, it is possible to move the growing into the restaurants and create an opportunity for restaurants to have their own.

DIRECTION SHIFT

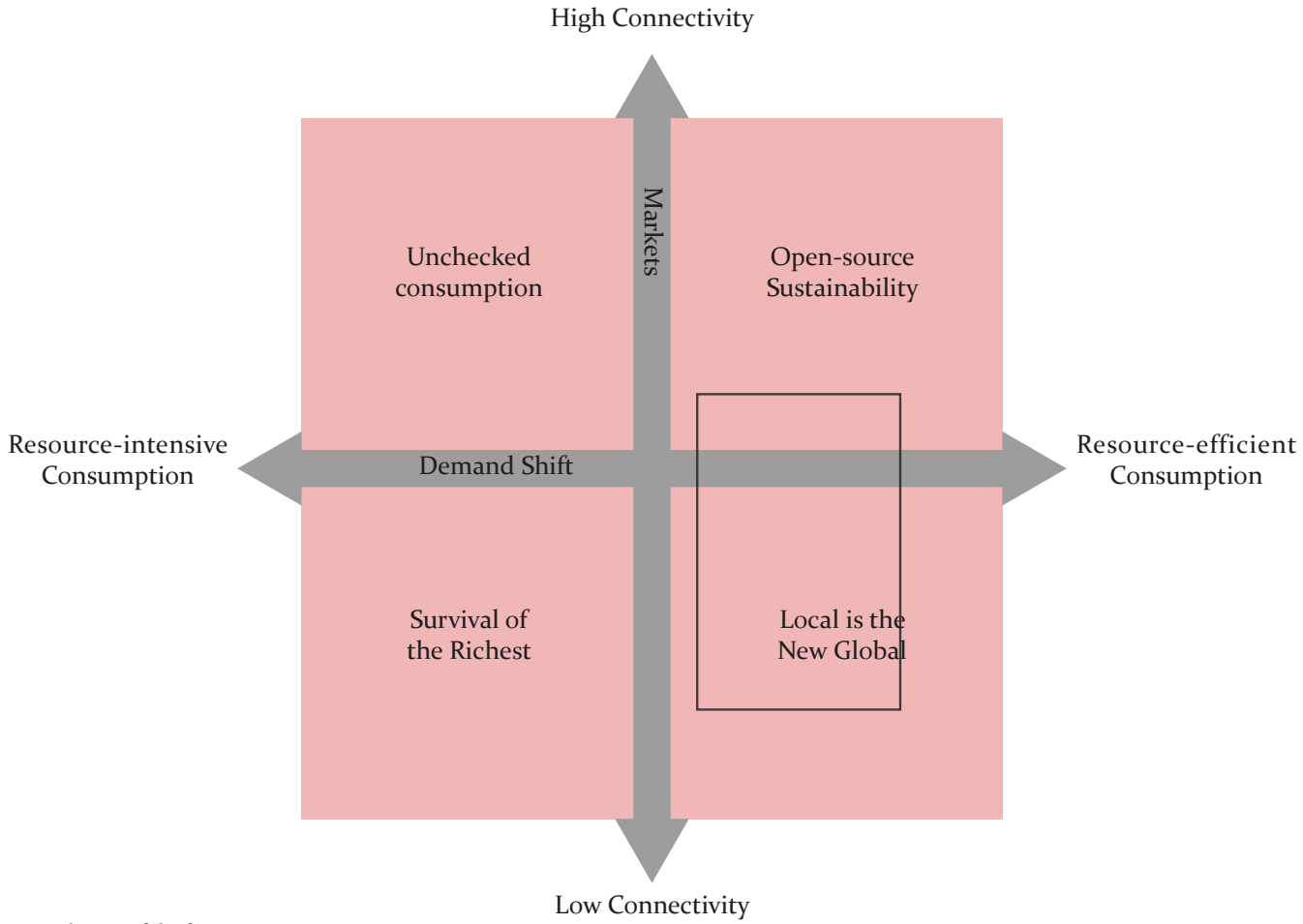
After looking closer at the context it was discovered that the possible solution space for indoor apartment gardens would be more a gimmick than solving an actual problem. Therefore it was chosen to search for a problem within urban agriculture which would give a larger playground for the project and give an opportunity to solve a deeper problem.

INITIAL THOUGHTS ON URBAN AGRICULTURE

There is a rising need to re-think the worlds food system. In the future, the earths food capacity will bed depleted by the growth in the planets population, 10 billion by 2050. 66% of the population will, by then, be living in the larger cities. We will run out of available land because of overpopulation and land damage over time. [Nayyar, S., Dreier, L. 2017]. To prepare for these conditions there is an agreement on some sustainable goals for 2030, regarding food security, nutrients, less transportation and less water waste. [Sustainabledevelopment.un.org]
To put these numbers in perspective, the world as of 2019 uses the landmass of South America for producing food and by 2030 the world will need an extra landmass as big as Brazil (ill. 5). Land the world does not possess. [Despommier, D. 2011]

Ill. 5 - Map of South America and Brazil

From this, new business opportunities are emerging in the agriculture world due to the rapid growth in demographics and massive local immigration to major cities. [Business and Sustainable Development Commission, 2016]



Ill. 6 - Prediction of the future

FUTURE OF AGRICULTURE

The world needs to change and a prediction of the future was made by World Economic Forum [Nayyar, S., Dreier, L. 2017], where four different possible scenarios are explained.

Every prediction can come true in 2030 and there will probably be a mix of them all depending on what country you look at (ill. 6). The team looked into the future of "local is the new global".

In this prediction, every country focuses on feeding its own citizens before exporting their goods to others. This will mean that only local produced food will be available at a fair price. People will be more focused on healthy nutrient-rich food and political as well as social initiatives will be in place to have a resource efficient consumption.

FINAL DIRECTION

For both a indoor apartment gardens and urban agriculture directions, it were realized that the access to context and users was limited. So instead of looking at the problem as to "save the world", the team wanted to make a dive into a specific area. In a interview with the local farmer Pia Hjort [WS06] she mentioned that she deliver seasonal greens and potatoes to restaurants in the area. The team found this interesting and wanted to look into where the restaurants get their greens from outside of season, and if there are any problems with retrieving greens off season in Denmark.

EVALUATION

A lot of directions were looked into, discovered and discussed during the first week. It was frustrating and the team did not feel they could find a solid place to stand. The "saving the world" approach was too wide without a buyer or problem owner, and therefore it was chosen to dive into a part of the problem or a "solution" to the problem, which could be in local farming. The next step is to look into restaurants, ecological and healthy food trends to find a place to stand and a validated challenge for a potential customer within the supply chain of greens.

RESTAURANTS AND ECOLOGY

ECOLOGICAL FOOD TREND

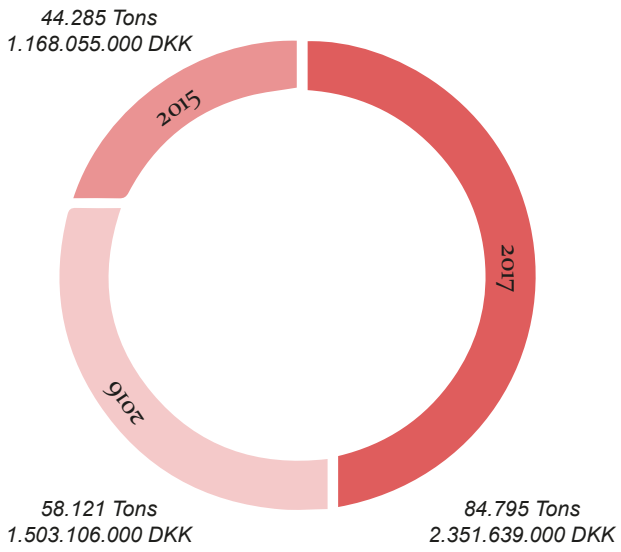
To understand how ecological food is currently trending in Denmark, and how the restaurants, cantines and cafes are adapting to new customer demands a trend analysis was made.

In Denmark, citizens have become more aware of the quality of food. Both in the taste of the food as well as its origin. As a result of this, Denmark is the most ecological country in the world. [If.dk]

This can also be seen in the restaurant business. Restaurants have adapted this trend due to consumers demand where the customers have become more aware of where the food is from, how far it has traveled and if the farm that delivers the food is paid fairly.
All these demands have resulted in a new understanding of food which gives the restaurants some new concerns that do not just deal with the traditional taste and experience at the restaurants. Now the important story for the customer is more about what happened before the food entered the kitchen and not how they cook it at the restaurant.

The restaurants needs to reinvent itself and take new factors into considerations when running their business. The focus when running a restaurant is shifting from taste to corporate social responsibility [Danskerhverv.dk] in the sense that customers do not want to eat at certain restaurants if the food is not in line with the new trends.

This can be seen in (ill. 7) where the Danish use of vegetables from 2015 - 2017 has almost doubled from 44.285 tons to 84.795 tons.[Dst.dk]



Ill. 7 - Use of vegetables in Denmark

This trend has set its mark in the Danish restaurant business. From 2012 to 2018 more restaurants has followed their customers and converted their business model to meet these ideals. Shown in (ill. 8) there were 94 restaurants and commercial kitchens in Denmark who had the identity of being an organic restaurant in 2012. In 2018 the number has risen with 2824% to 2655 restaurants and commercial kitchens. [Oekologisk-spisemaerke.dk]

To become an organic restaurant and a member of "Økologisk landsforening" there are three criteria:

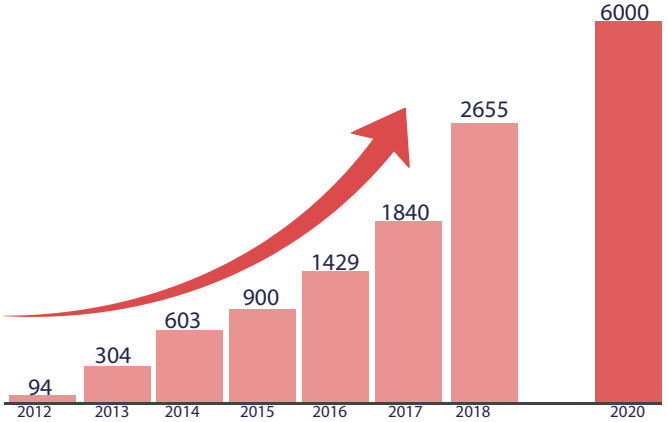
- Using organic food, at least 30% of the total weight.
- Being waste oriented (subjective evaluation)
- Using local foods (Part of the food supply chain has to be local)

SUMMARY

Consumers are eating more organic food than ever before. The restaurants are reinventing themselves in how the food is perceived. Focus has shifted from taste to story and with that, the customers demand a new type of quality; origin, ecologic and responsibility. The restaurants are becoming more aware by being part of the "Økologisk landsforening".

REFLECTION

The demands of ecology and social responsible vegetables are rising. Furthermore, the restaurants are beginning to catch on to this trend and shaping their business to complement their customers. Next step is to interview and visit restaurants to verify the trends but also identify design problems that could be within the scope of looking on the vegetable food situation surrounding Danish restaurants.



Ill. 8 - Registred organic restaurants in Denmark

INTERVIEWS WITH RESTAURANTS

The purpose of these interviews was to identify how they see the business as of now, what challenges they face and if they can be solved with an industial design product. The main objective was to discuss the food system, customer demands, how they cope with problems and where they see opportunities. The interviews were conducted by telephone.

INTERVIEW RESTAURANT KEHLET

At restaurant Kehlet, Vegetables are a vital part of the daily courses. They rely heavily on them in their meals. Even though they have daily delivery on vegetables and greens the challenges are still present. Some of the challenges are:

- Delivery of greens every day except Sunday
- Price is volatile, 40% can be added to the price, which is difficult to budget with
- Damaged greens from southern Europe
- Some leafy greens are hard to get

For all challenges see [WS05].

INTERVIEW FLADBRO KRO

Jonna from Fladbro Kro was interviewed to relate some of the problems Kehlet have to identify similarities.
The full interview is displayed in [WS08].

Fladbro Kro has a large food supply chain, even when only looking at their supply chain surrounding vegetables. They are very aware of their food story and have taken different initiatives to use more locally grown vegetables. They still have leafy greens delivered from southern Europe and in total, they get delivered vegetables and leafy greens 4 times a week where leafy greens account for 4 kg a week. They are very aware of their customers expectations and try to meet them by having mainly organic vegetables and leafy greens. They have cut down on exotic vegetables because of this, but it limits them in what they can have on the menu. Right now the leafy greens are used to sell the courses and do not bring in revenue because of the high delivery price (1000 DKK per delivery) and the price itself for leafy greens and microgreens(500 DKK per week).

Fladbro Kro is seeking funds to build their own urban garden in order to grow vegetables and leafy greens themselves because the customers are demanding it and see this as a way to differentiate themselves from their competitors. But this will only deliver seasonal greens to the menu.

EVALUATION

Leafy greens are very important for the restaurants. The food supply system makes it hard to get a reliable delivery both in price and getting actual healthy and tasty leafy greens. Fladbro Kro has a huge supply chain for vegetables and leafy greens. The one where they lose money and quality are AB catering which is delivering imported leafy greens. Fladbro Kro uses 4 kg leafy greens a week for the visual sale of the course. The customers demands have a huge impact on their decision to not use exotic leafy greens because it can not meet the standards expected.

REFLECTION

These interviews have given the team a hunch of where there could be something to solve through industrial design; Exotic leafy greens. This needs verification through further research and visits at the restaurant. Before going to deep into the problem the team wants to unfold the solution space by interviewing companies that are currently trying to solve the problem.

ADDED DESIGN DEMANDS

- Grow usually imported greens
- Produce 4 kg of leafy greens and microgreens a week
- An integrated solution to the restaurants
- Should match the price they pay for greens today
- Reliable delivery

Ill. 9 - Different parts of the restaurants supply chain consisting of import, local farmer or own garden.

FLADBRO KRO SUPPLY CHAIN

The food system were mapped to illustrate how the restaurants' supply chain looks like and where there is an opportunity to focus on.

Most leafy greens the restaurant uses is delivered from southern Europe and transported to the restaurant. The restaurant tries to use local fresh leafy greens and microgreens as much as they can.

The only thing they want more is to use greens from a forest nearby or establish their own small agriculture. The customers expect that the restaurant uses these resources as much as they can. There is an opportunity to design a solution that can make the delivery of exotic leafy greens and microgreens more reliable, cheap, sufficient and higher quality so it fits into the customers' demands of local food.

INTERVIEWS WITH INDOOR FARMS

Ill. 10 - Nordic Harvest logo

The purpose of these interviews was to get a notion of how the field in growing exotic leafy greens is in Denmark and how it is to have a viable business from it. A potential visit was the overall goal for learning about how normally imported leafy greens are grown in Denmark.
Therefore Anders from Nordic Harvest and Mikkel from BIOARK were interviewed by telephone.

INTERVIEW WITH NORDIC HARVEST

Nordic harvest is a company that aims to produce 350 tons of leafy greens a year. They want to make their revenue by producing huge amounts to cut the price on their own crops to match the market price but still have the added value of freshness, taste and local produced. They do not sell to restaurants because they can not sell enough to have a viable business model. They sell to supermarkets because they have a larger demand.
Throughout the interview with Nordic Harvest, the technical aspect of how to grow leafy greens in Denmark was uncovered. A heavy technical setup is required to grow leafy greens for supermarkets in Denmark. The following are essential for growing leafy greens.

- The right light spectrum
- Airflow
- Temperature
- Nutrients
- Water flow

To start a production you have to invest a lot of money but as the indoor agriculture business is growing the price on the technical components will be cheaper. Furthermore a setup is very complicated to make because there is no standard product. To read the whole interview see [WS09].

A visit at Nordic harvest was requested but their facilities will not be ready until July. Until that point, it will just be an empty warehouse and therefore not relevant to visit.

SUMMARY

Nordic Harvest is targeting supermarkets because of the quantity they need. Restaurants do not request enough to set up a supply chain to service them. The buy-in to growing leafy greens is high but will be cheaper in the future.

REFLECTION

The team had a hard time getting a foot into this business to experience and gather knowledge on how to grow leafy greens in Denmark. This was frustrating because a lack of knowledge resulted in difficulties with seeing a solution space for solving the restaurants' problems with importing leafy greens.

BIOARK

Ill. 11 - BIOARK logo

INTERVIEW WITH BIOARK

The purpose of this interview was to get insights from a business that lives of establishing gardens for restaurants and kitchens and also hydroponic systems for the social garden initiative.

BIOARK was convinced that the urban agriculture business has come to stay because of the advantages of growing exotic leafy greens, the history about locally grown greens and flavor of the greens. BIOARK has established urban gardens for a lot of different restaurants in Copenhagen. Noma and Restaurant AMASS has the most advanced systems and the team was urged to visit them to see how a system with both traditional agriculture and hydroponics are made and maintained.

Sustainability was discussed as a reason to shift from importing to establishing local gardens. Here Mikkel uncovered why this might not be the case. Added power consumption to growing crops and production cost for making setups will add up in the same amount as importing leafy greens. For a transcript of the whole interview see [WS10].

SUMMARY

BIOARK is a company build on the knowledge of establishing urban agriculture sites in Copenhagen. They have established agriculture for AMASS and noma with great success. Sustainability is not the main focus when establishing urban agriculture.

REFLECTION

This interview gave the team an idea of how a new business on its way to blossom thinks. But when nothing is established and the business is trying to define itself, it is hard to get access to observe, analyze and challenge the system with design proposals. At this point, the team was still frustrated from the lack of collaborative partners that could help uncover the real challenges and opportunities in this field.

CONSIDERATION OF PIVOT

Because the team had a hard time getting into the context to observe an indoor farm, other directions for the project was considered. Without a way to visit and observe an indoor farm, the team did not find it possible to make a valid project. But after that an interview with Nabo Farm, a indoor garden facility, was arranged.

INTERVIEW WITH NABO FARM

The purpose of interviewing Jens from Nabo Farm by telephone, is first and most to get a visit, a collaboration partner but also to uncover the challenges they face by having an urban agriculture with a hydroponic setup.

Nabo Farm is a business which sells microgreens and leafy greens to restaurants and corporate canteens. The canteens can either buy delivered greens from Nabo Farms own setup or rent a setup that Nabo Farm make service on.
Nabo Farm has existed since November 2018 in a little storage hall with a small setup where they mainly focus on microgreens because the sale of them brings a steady and reliable revenue. The name comes from their concept where they want to be neighbor to their customers in order to deliver greens locally, and preferably by bike. Their customers have sustainability, local and fresh as core values and therefore their food has to match that.
When growing leafy greens, as Nabo Farm does, there are some problems to look into:

- Integration of Nabo Farm to the restaurant supply chain.
- From farm to plate situation. Can it be optimized or redesigned?
- Packaging to fit customer value and fit delivery by bike.
- Harvest situation.
- There are no standard products. Components do not fit together. The product system around urban agriculture is very DIY.

Nabo Farm points at the urban agriculture as the start of a whole new business where nothing is set in stone. They are building their business on trial and error as well as everybody else in the indoor farm business.
The interview ended with an agreement of a visit where Jens would explain and show how they grow leafy greens and microgreens for canteens and restaurants. To read the full interview see [WS16].

Ill. 12 - Nabo Farm logo

IMPORTANT INSIGHTS

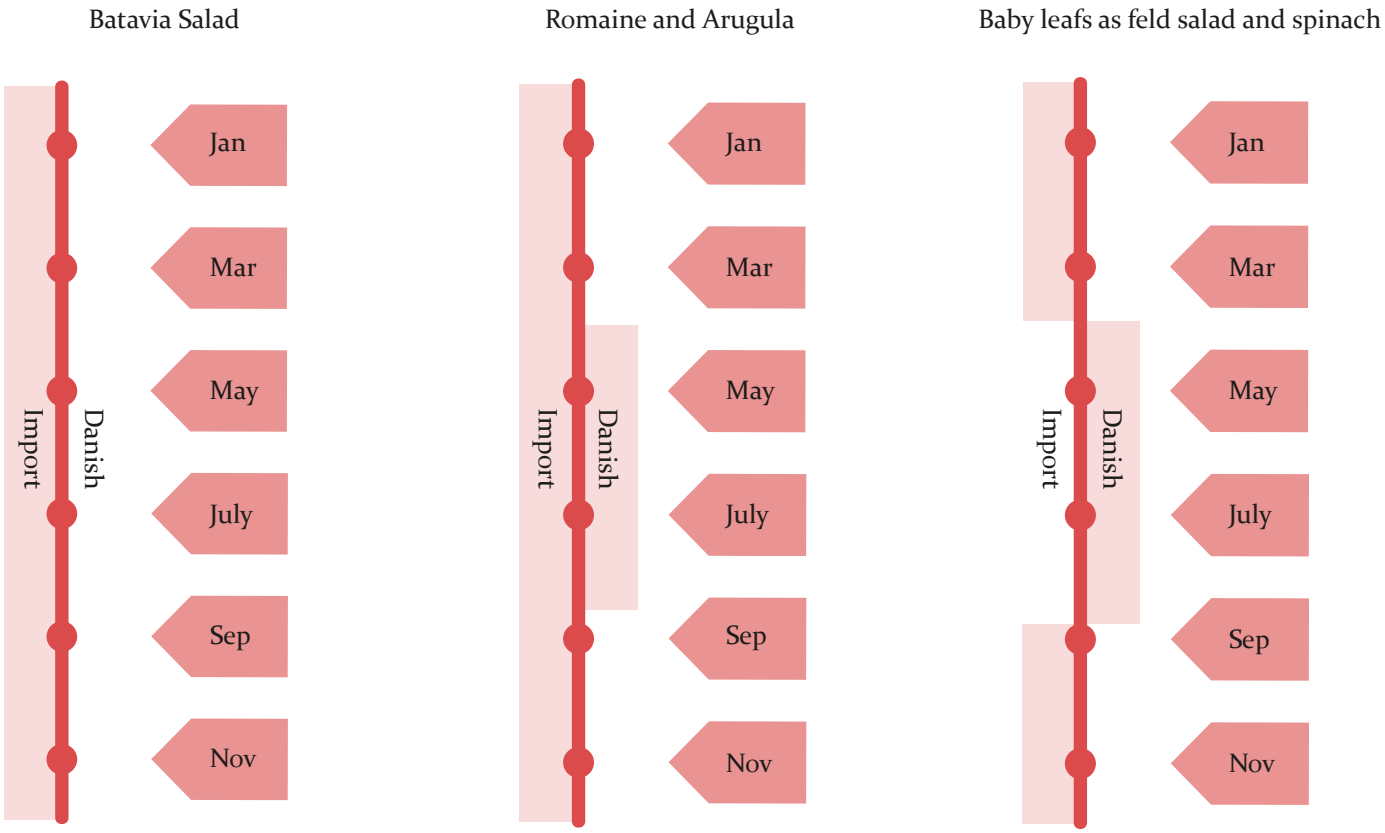
- Urban agriculture as a whole new business
- No standard in the products the business uses
- There is a demand from restaurants
- Sales through customer value and not economic gain
- Visit planned at Nabo Farms facilities

EVALUATION AND REFLECTION

This interview with Nabo Farm was a turning point in the project. Now there was no need to make a pivot because of the access to the business. Interesting points was uncovered and needs to be investigated further. It is not clear yet if the teams focus should be in designing a product proposal for companies and entrepreneurs such as Nabo Farm or focus on the restaurants. There is still a lot of questions about how to grow leafy greens and microgreens in Denmark. This will be uncovered in the next step which is a visit to Nabo Farm and Fladbro Kro.

ADDED DESIGN DEMANDS

- Should be able to change the amount based on demand
- Should be plug and play



Ill. 13 - Danish and imported leafy greens displayed in availability

IMPORTED GREENS

To determine what kind of leafy greens and microgreens that are not obtainable in Denmark, the team looked into companies who import these to discover what kind of leafy greens and microgreens the project should concern. A quick research were done to see what leafy greens are imported in the supermarkets. This was done to get a notion if there was any. It is documented in [WS02].

Grønttorvet Copenhagen is a vegetable wholesale company located in Copenhagen. They sell vegetables to other suppliers to be distributed in all of Denmark. They have made a table of where the vegetable they sell come from on every given month of the year. This is for their buyers to see when they can buy kale if they only want danish kale and so forth. [groenttorvet.dk]
They rely heavily on import from Spain, Italy and Holland of leafy greens like romaine, arugula, spinach and microgreens in general as shown in (ill. 13).
To see the full list of what kind of leafy greens and microgreens are imported and what is grown in Denmark see [WS18].

EVALUATION AND REFLECTION

The main suppliers of leafy greens and microgreens rely on imported greens to serve their customers when the season is not to grow these crops in Denmark. The next step is to interview and visit restaurants to see if they use these kinds of leafy greens and microgreens and in what quantity they use it. Future interviews will also be used to disclose if the restaurants are interested in using danish grown exotic leafy greens and microgreens.

ADDED DESIGN DEMANDS

- Grow usually imported greens.

Ill. 14 - Kitchen and Jonna at Fladbro Kro

Ill. 15 - Parsley imported from Italy

VISIT FLADBRO KRO

The objective of visiting restaurant Fladbro Kro was to understand the context, talk about potential problems with the owner and understand the workflow at a restaurant. This information should be important later in the process when developing a possible solution.

Fladbro Kro is a restaurant that earns its revenue of ala carte sale of courses at night and delivering courses to larger events at day. The restaurant is divided into three sections; one for ala carte guest and two for larger events. For them, the problem is within the a la carte side of their business because this is mainly where they use leafy greens and microgreens. They can only serve seasonal leafy greens and microgreens, if they only should use local greens, because the ones they use is very season depended. Both issues is cause by different season means different fresh greens and vegetables, but also because they want to offer their customers something local but still new and exciting, but they cannot leave out the imported greens at this point, they are too important.

The restaurant operates and interacts in their daily work through three places.

- The kitchen where the food is cooked
- The storage room where food is stored to keep it as fresh as possible
- Out in the backyard where they gather flowers and herbs.

A possible solution could be incorporated into one or more of these three contexts.

In the kitchen, the leafy greens and microgreens could be placed for the purpose of using directly in the food. In the storage, they could be easy to spot and unpack or pack. Out in the backyard, there could be an opportunity for the guests to see what is grown or interact with the solution. A value for them is the possibility of a huge variety of different greens depending on the type of food and season.

Ill. 16 - Micro greens stored in Condi plastic bucket

Ill. 17 - Storage shelves for vegetables

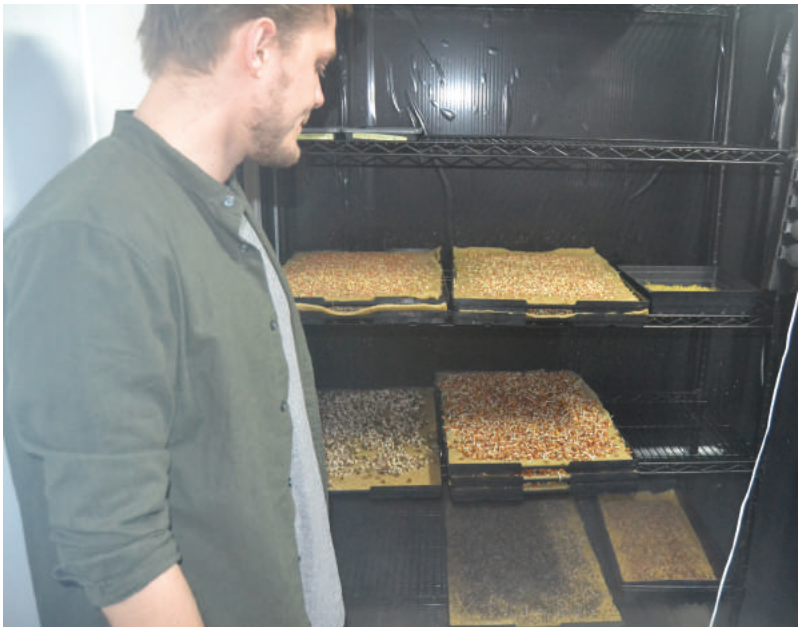
They get delivery of greens 4 times a week where they quickly put the leafy greens and microgreens in the cold storage room to protect the plants. They use less than an hour a day to harvest from their small kitchen garden and the forest nearby. But are still depending on imported greens. When they have some leafy greens and micro-greens to spare they try to use it in stews to use every gram of what they get from the delivery service. Limited food waste is a very important part of their business because the customers demand it. To read further about the visit at Fladbro Kro it is documented in [WS17].

EVALUATION AND REFLECTION

Fladbro Kro is in need of a product that can solve their problems regarding leafy greens and microgreens. At this point, there is a potential to solve their problems regarding delivery of leafy greens and microgreens. The next step is to understand how to solve their problems and if it is possible. This will be uncovered in the visit to Nabo Farms urban agriculture in Copenhagen.

ADDED DESIGN DEMANDS

- Integrated into storage scenario
- No need for packaging



Ill. 18 - Microgreens germination room

Ill. 19 - Plugs for pre-growing to Zipgrow tower

VISIT NABOFARM

The objective of the visit at Nabo Farm is to observe and learn their methods in how to grow leafy greens and microgreens indoor, the technical setup and identify possible challenges that may occur when having an indoor agriculture setup. [WS19]

Nabo Farm is located within an old storage hall where they had to build a room to grow their greens in. From here they can control things such as humidity, airflow and temperature. In one side of the hall are the microgreens that take them 7-10 days to grow depending on the crop and on the other side is the leafy greens that take 21 days to grow to a saleable size.
The microgreens are placed in a humidity chamber to germinate in 2-3 days(ill 18), thereafter they are placed under grow lights and are ready 5-7 days after. The leafy greens are placed as a seed in a plug under grow lights for 4 days until they are ready to be placed in vertical zipgrows(ill. 21) with grow light and automatic water system.

Nabofarms productionline:

- Receive order
- Plant seeds
- Check if growing right and water level in tank
- Harvest leafy greens or microgreens
- Pack in condi buckets
- Deliver to customer

Nabo Farm seeds and harvests all the time as a result of their diverse customers. They have an automatic system to keep track of what leafy greens or microgreens are grown for whom and an automatic system to water the plants. The rest of the operations are performed manually, as the current production scale can not support a fully automatic process.
The team got a view of different technical setups and which constraints and advantages the different ways of growing leafy greens and microgreens have. This will serve as a good first-hand experience in understanding what type of system could be used in the development of a product proposal.

Ill. 20 - Automatic Farm shelves for both microgreens and pre-growing

Ill. 21 - Zipgrow towers for leafy greens

EVALUATION AND REFLECTION

Nabofarm as a business still uses trial and error in what works and does not work when growing leafy greens and microgreens. They have different procedures and ways to grow and it all has its advantages and disadvantages. The team needs to look into what the restaurants are capable of themselves and what they need help with, to find a design solution to their problem. It is very hard to find a design problem within the indoor agriculture because they do not themselves know what they need and if solutions will be sufficient for them, because they are still in the process of figuring themselves out.

ADDED DESIGN DEMANDS

- Should be a controlled environment

COPING STRATEGIES

To discover how the restaurants cope with the issues of damaged greens, variation in price, bad taste and lack of freshness, in what they get delivered from southern Europe, the team investigated which alternatives the restaurants use to deliver the desired value to their customers in leafy greens and microgreens [WS12]. These are based on observations in Copenhagen [WS19].

ESTABLISHING AGRICULTURES

High-end restaurants are establishing traditional agriculture next to their restaurant business. These agricultures exist solely on delivering greens to the restaurant who owns it. This coping strategy comes with a high startup cost and 2-3 hours spend each day on maintenance.
Even though it can provide the restaurant with local grown vegetables, they are still depending on imported greens because of the climate in Denmark.

Ill. 22 - Traditional Agriculture

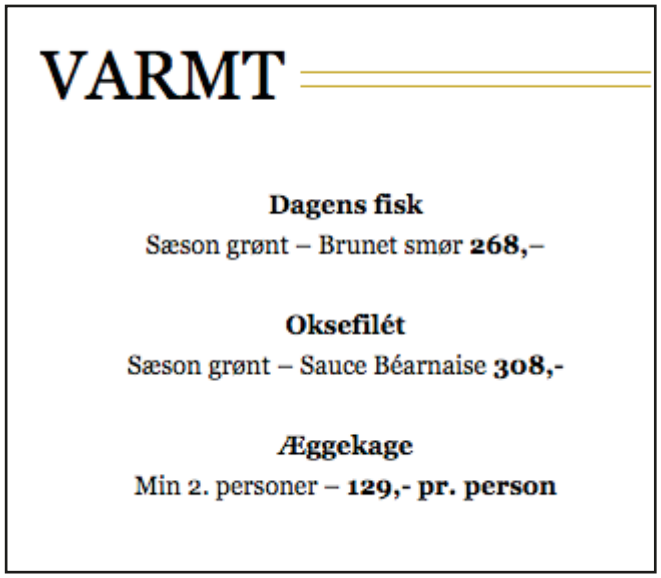
ESTABLISHING SMALL GARDENS

Restaurants establish back yard gardens to grow herbs and kale for themselves. Often they do not provide enough and depend on their supply chain to get what they can not produce themselves. Here the traditional leafy greens and microgreens are again not grown because of the climate in Denmark. They require maintenance, around 30 minutes each day.

Ill. 23 - Amass urban garden

NOT TELLING THE CUSTOMERS THE MENU CONTENT

Restaurants leave the menu card open in the sense of adding “greens” to the description instead of, for instance, Chard, arugula or romaine. This allows them to make the food with what the supplier can deliver. This saves them a lot of headache with broken promises to the customer but has no value because the customers do not know what they buy. This practice is looked down upon in the business because it is a bad service but the method is often used because of logistic reasons.



Ill. 24 - Notation of ala carte court at Fladbro Kro

EVALUATION AND REFLECTION

The restaurant business has various ways to cope. Some go all in and establish an agriculture. Other resorts to not telling their customers what they get in their food. These alternatives do not seem as optimal solutions, which is what the team want to work further with.

GAP ANALYSIS

FRUIT AND VEGETABLE DELIVERY SERVICES	
Pros	Cons
- No time used - Reliable delivery - Large assortment	- No security - Travel long - 7+ days old - Price variation - Delivery price - Low quality

LOCAL FARMERS	
Pros	Cons
- Nearby - Costum made - Fresh - Fair prices - High quality	- No delivery - Seasonal baverage - Limited assortment - Sold out fast

OWN FARMING SETUP	
Pros	Cons
- Near by - Control - Opportunity - Reliable - Resistant quality	- Time consuming - High startup cost - Takes up space

GAP 1

Not optimal because this gap suggest a timeconsuming solution with low quality.

GAP 2

This gap suggests a solution with medio to high quality but time-consuming.

GAP 3

This opportunity gap suggests a solution for high guality and is less time-consuming.

With the known coping strategies in mind, the team mapped where there is a gap in the market to target. With time spend and quality in mind, the different ways to have a leafy greens and microgreens supply chain was mapped with pros and cons and placed in relation to each other and the chosen parameters.

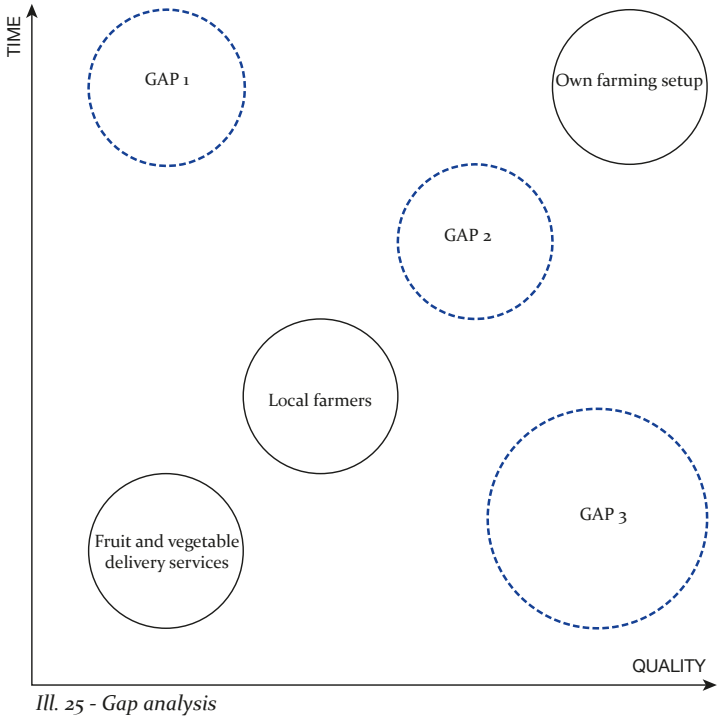
The team have discovered through interviews and observations that there are three different options; fruit and vegetable services, local farmers and own farm setup.

EVALUATION

There are different ways to look into how to approach the already existing market in acquiring leafy greens and microgreens. The first gap does not make sense due to much time used and low quality and will therefore not be looked further into. The second suggests a halfway service where farming setups meets the restaurants needs. The third suggests a solution for the restaurants that do not have the capital or human resources to establish own agriculture but still have the demand for leafy greens and microgreens grown at the site or nearby. It was chosen to look further into gap number three where the quality is high and the maintenance is low.

REFLECTION

This analysis is based on observations and interviews but is still subjective because it is based on the teams understanding of the market. The chosen gap will be discussed with restaurants further to determine if it is the right way to look at the market and its potentials.



Ill. 25 - Gap analysis

ADDED DESIGN DEMANDS

- Equal quality as locally grown vegetables
- Less time consuming than own farm setup

Ill. 26 - Define introduction

DEFINE

With the outputs from interviews and visits, the team used the define phase on collected the information and lined up challenges and possible principles which could be used to solve the challenges. The information useful to form the project was collected in a design brief.

Chapters

- Understanding the problem
- Design brief

PROVIDE QUALITY FOOD TO CUSTOMER EXPECTATIONS

PROVIDE A CULINARIAN EXPERIENCE | **BRANDING STRATEGY**

THE RESTAURENTS AIMS TO: PROVIDE A CULINARIAN EXPERIENCE

Neces - sity	RELIABLE DELIVERY	FRESH VEGETABLES	A RELIABLE MENU	FOOD QUALITY
Challenges	• The price varies with 40%. • The delivery is late caused by transport. • The vegetables are damaged before they arrive.	• It is old before it get to the restaurent because of food miles. • The tast is not optimal because the food is harvested long time ago.	• The restaurent does not promis the customer what kind of vegetables. • Need back-up menues in worst case.	• Restaurents prefer local or self-grown vegetables, but it takes time. • They dont know the quality before it is delivered.
Solution principles	• Have close partners. • Locally grown. • Deliver it yourself.	• Locally grown. • Minimal storage. • Minimal transportaton. • Better storage. • Harvest often.	• Acessability to needed food. • Reliable delivery.	• Fresh food. • Local food. • Lot of taste and nutritions.

BRANDING STRATEGY

Neces - sity	CUSTOMER EXPECTATION	COMPETITVE EDGE
Challenges	• Expect local food. • Expect tasty food. • Expect fresh food.	• It is difficult to stand out from other restaurants.
Solution principles	• Setting up own garden. • Setting up hydroponic system. • Contact local farmers to grow for you.	• Branding themselves by standing out. • Organic restaurants are raising in number and popularity.

UNDERSTANDING THE PROBLEM

To define the problems the restaurants face, regarding the leafy greens and microgreens situation when running a business, the team tried to break down the problems in order to understand the challenges and possible solutions principles. [WS14]

Breaking down the challenges was to state the top goal for the restaurants and break it into sub-goals that all have to align to provide quality food which meet customer expectations. Furthermore, it was divided into a culinary aspect and branding aspects, to get a view of what it means for the restaurants.

EVALUATION AND REFLECTION

The attempt to map and break down the core problem for the restaurant when talking leafy greens and microgreens was not deep enough. This was due to a lack of understanding of the restaurants. A revisit were needed to understand the core of the problems and what really matters for the restaurants. Next step will be to develop product solutions to test with the restaurants to see if this will allow a better understanding of the problem for the team and what actually matters for the restaurants.

DESIGN BRIEF

PROJECT OVERVIEW

There is a rising trend in customer expecting local grown and higher quality which leads to restaurants growing their own vegetables for better quality, reliability and branding advantages. The average restaurants today use a delivery service who mostly gets vegetables from outside of Denmark. When imported vegetables get to the restaurants, they are mostly already 7+ days old. High-end restaurants are coping with the wish for locally grown vegetables and better quality by using local farmers, own city gardens or even buying a farm for this purpose. A culinary experience is expected, and with locally grown vegetables the taste, visuality and story has a greater value.

PROJECT AIM

This project aims at designing a product solution for high-end restaurants that want to use local food to ensure quality and delivery security to not be dependent on imported greens from southern Europe, while also being a product that can give a stronger branding foundation.

TARGET GROUP

As a target group, the team sees two possible primary users; Restaurants and customers at restaurants. With a product for local grown vegetables, the restaurants can satisfy the customers expectation for high-quality food when they go to high-end restaurants to eat. The customers going to a high-end restaurant expects a culinary experience with fresh and tasty food from local farms, arranged in a visual pleasing serving.

SCOPE

The team has decided to focus on products for high-end restaurants because they have the largest base and wish for high-quality food and stand out branding strategy. Also, the focus will be on leafy greens and microgreens because these are seen as the most optimal vegetables to grow indoor, and high-end restaurants have most problems with getting these fresh from delivery services.

In this thesis 4 main challenges in this scope are present:

- How to ensure reliable delivery of leafy greens and microgreens for the restaurants?
- How to solve the challenge of 7+ days old leafy greens and microgreens being used by the restaurants?
- How to ensure that leafy greens and microgreens are a part of the menu and not an uncertainty?
- How to give the restaurants a tool to make quality food from leafy greens and microgreens regardless of the season?

VISION

To make restaurants self-sufficient.

MISSION

Give restaurants the possibility to use locally produced leafy greens to match their needs for quality and delivery.

BUSINESS POTENTIAL

The urban agriculture is starting to flourish because of the rise in demand for locally grown leafy greens and microgreens in Denmark. This new agriculture business is very young and not developed. There is potential to place a product for a potential customer that is overlooked right now; the restaurants. These restaurants spend 1000 DKK on delivery of leafy greens, and 500 DKK on the leafy greens and microgreens, a week. Here there is a potential to add value through taste, freshness and visuals as well as an economic gain for the restaurants.

With the rise of consumers awareness of quality in leafy greens, new business opportunities are rising. ecologic and local food are permanent in Danish supermarkets and very popular. Other aspects of the food system are also being followed closely by consumers. Food miles, days in storage, flavor and water usage are parameters consumers are choosing their vegetables from.
Restaurants are having a hard time keeping up with these consumer demands and cope by having either heavy investments in own agriculture sites or leaving usually imported vegetables out of the courses.
Furthermore organic restaurants in Denmark are on the rise and has gone from 94 in 2012 to 2.655 in 2018. The number of consumed vegetables have doubled from 2015 to 2017. A urban agriculture business can not make a viable business out of selling to restaurants because of the infrastructure affiliated with from planting a seed to delivery to the restaurants.
Therefore there is a need for restaurants to have a solution which can ensure the quality consumers demands together with not having to invest heavily in agriculture with both time and money.

DELIMITATIONS

- Urban agriculture is represented by a variety of different business types. Large scale farms and in-home products are not the focus area. Large scale because of the lack of the option to explore the context which is most in Holland, England and Germany in Europe. In home products because of the it is more hobby based and therefore will not solve any critical problems in the near future.
- The first movers in this local farming trend are high-end restaurants and larger public workplaces as kindergartens, schools and so on. The project is not focusing on public workplaces because they have a restricted economy compared to a high-end restaurant.
- Also, the team delimitates from designing a product proposal for other vegetables than leafy greens and microgreens because the largest need is seen for leafy greens and microgreens vegetables within the catering business.

DEFINED DESIGN DEMANDS

- Produce 4 kg a week
- Should match the price of greens today
- Grow usually imported greens
- No need for packaging
- Grown in a controlled environment

ILL-DEFINED DESIGN DEMANDS

- Integrated solution for restaurants
- Reliable delivery of leafy greens and microgreens
- Should be plug and play
- Able to change the amount produced based on demand
- Integrated into storage solution
- Less time consuming than own farm setup
- Equal quality as locally grown vegetables

Ill. 27 - Deliver introduction

DEVELOP

With the defined design brief, the team were ready to go into develop to try and find a good solution for the challenge of getting fresh and local grown leafy greens and microgreens. Here initial ideation led to three concepts, testing and feedback from the target group.

Chapters

- Initial ideation
- Three concepts
- Testing and feedback

INITIAL IDEATION

ROUND 1

To kickstart the development phase the team tried to organize how to structure the sketching process. Four different topics were decided on and principles to take into considerations was listed.

The four topics were:

- Redesigning a raised bed which is used by restaurants at this point but is not working optimal
- The vegetable garden which uses natural resources
- The local farm which can grow on order and has lots of different sorts
- Indoor restaurants where storage and efficiency were in focus (plug and make)

Within these topics were different core principles that the team wanted to bring into their concepts as the example below shows. A vision of what the team wanted to go from and to was also stated in the topics. The four topic sheets can be seen in [WS20].

REDESIGN RAISED BED

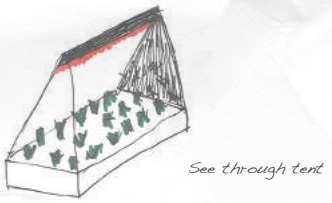
CORE PRINCIPLES FROM TODAYS PRODUCT

Over the ground
Moveable
Stackable
Modular
"Part of outdoor area"
Take crops when needed, no full harvest
Less food waste

FROM	TO
High maintance	Low maintance
Season based	Not season based
1 sq. m.	1+x sq. m.
Outdoor	Anywhere
Non reliable	Reliable
Soil	No soil

QUESTIONS RAISED DURING IDEATION

Vegetable garden

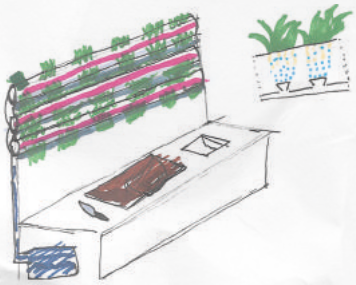


Ill. 28 - Grow tent for exotic vegetables grown outside.

Redesign raised bed

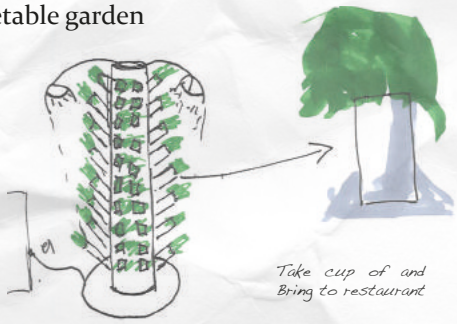
Ill. 29 - The farmer grows the crops at the restaurant

Plug and make



Ill. 30 - Grow the grops right next to the preperation table.

Vegetable garden

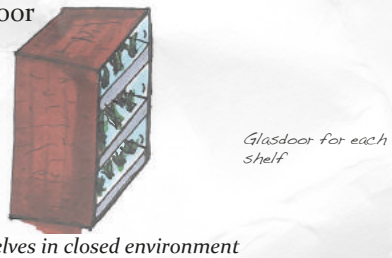


Ill. 31 - Grow the crops and bring what the restaurant needs

EVALUATION

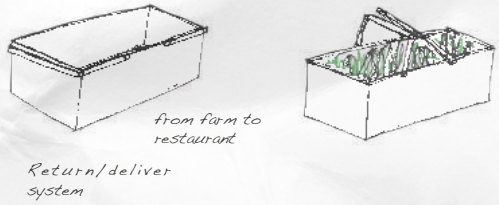
The first sketches were to get the initial ideas out of the head. There was one thing that was consistent in the sketching; The placement of the product proposal. In the restaurant, outside the restaurant and local farm close by. These topics were taken into the next sketching round to ideate further on.

Indoor/outdoor



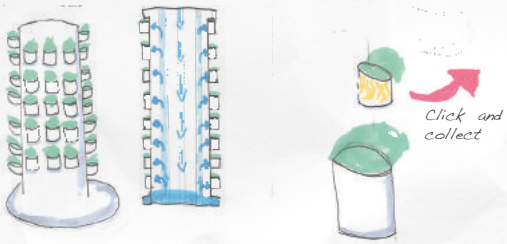
Ill. 32 - Grow shelves in closed environment

Transportation



Ill. 33 - Basket to transport, therefore no need for plastic

Tower



Ill. 34 - Click off salads in box and transport it to restaurant

Blocks

Ill. 35- Zipgrow tower that can be devided into small cubes

ROUND 2

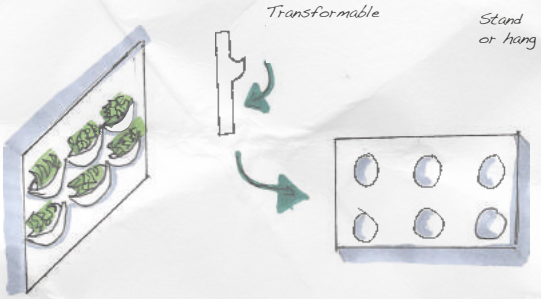
To keep a direction for the next sketching round the team set up some criteria to implement into the sketches. [WS21]

- Handling process
- Delivery
- Reliability
- Transportation
- No seasonal (technology)
- Need to produce 4 kg pr week.
- Continually delivering greens.

Indoor all in one

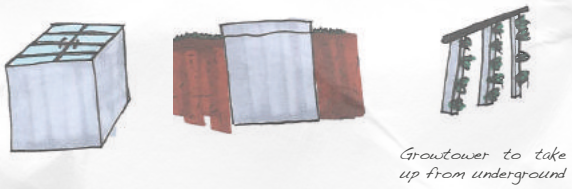
Ill. 36 - Grow shelves in closed environment

Transformable wall for taking the salad into kitchen



Ill. 37 - Turnable bowls for growing different vegetables

Underground bunker



Ill. 38 - Underground bunker for controlled invironment

ROUND 3

After the third sketching round three principles was chosen for further develop. The process of sketching and ideating was very difficult. Not enough knowledge of hydroponics systems and the context made the ideation phase fuzzy and not clear enough. Now the team will build the three concept principles as simple mockups and test it with potential customers to see if it fits their needs and what the team has missed in the research phase. Then according to the feedback, there is maybe a need for going back and visit ideation phases again to see if the new knowledge acquired has changed something in the starting phase of developing the product proposal. [WS22, WS23]

THREE CONCEPTS

PURPOSE

The sketches needed to come “alive” through mock-ups to explore size, technology, initial user scenarios and grow capability.
Three concept principles were chosen from the sketches to create mock-ups from. One “bunker” to grow outside, one modular to complement every restaurant need for leafy greens and microgreens and one “cube” to place inside the restaurant. [WS24]

BUNKER CONCEPT

The bunker is made to be underground to avoid taking up any space but still produce a lot of leafy greens or microgreens. Inside there is space for six vertical “grow towers” where the seeds can flourish to become leafy greens in a closed environment with light and water.

Take a tower up from the box. Place the grow medium inside with seeds and put the tower back in. After three weeks there will be leafy greens.

CUBE CONCEPT

The cube is made to be displayed in the restaurant. Each cube should serve one customer with leafy greens and microgreens. The concept is to have the customer decide their own greens and have the waitress hand it over to the chef in the kitchen.

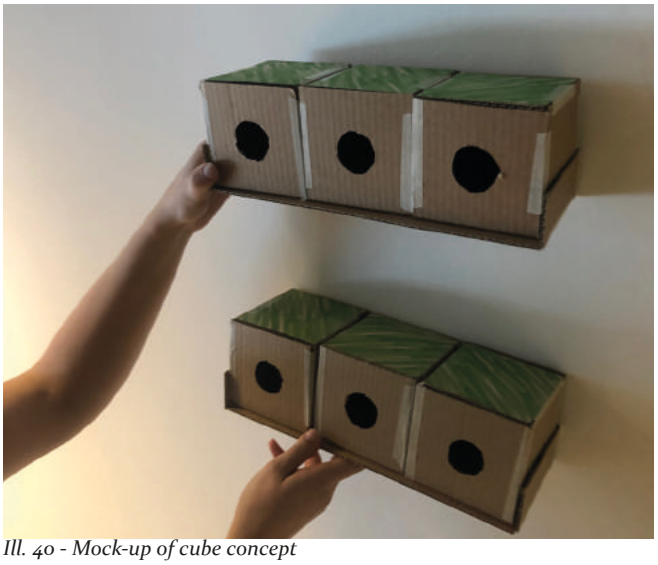
MODULAR CONCEPT

The modular concept is for the restaurant to have the opportunity to build their own system. Both in size and shape. The small rectangular shapes make it easier to stack as much as the space they have available allows. Here it is also easier to help the restaurants make their own system based on how much they need.

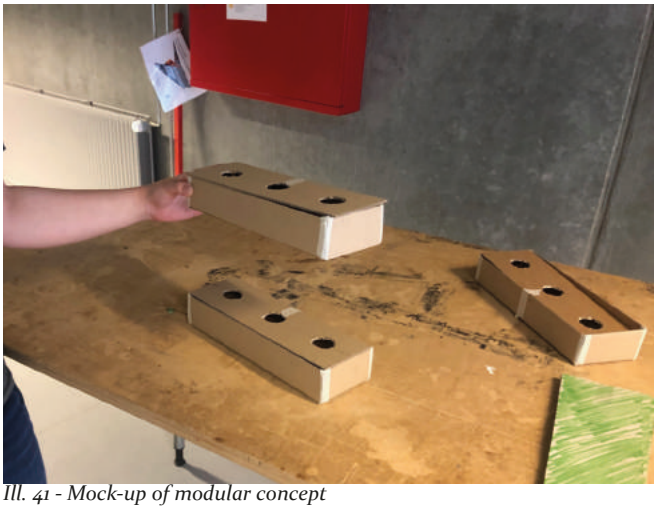
STATUS SEMINAR 1

At the status seminar the team realized that the target group, context and market should be understood and specified more. This could give a deeper understanding of the problem and the solution which the user would need.

Ill. 39 - Mock-up of bunker concept



Ill. 40 - Mock-up of cube concept



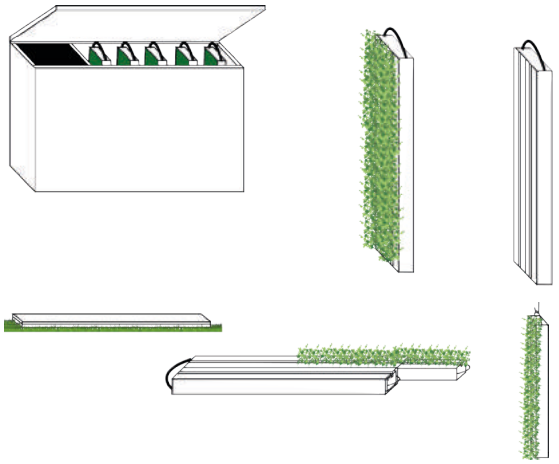
Ill. 41 - Mock-up of modular concept

TESTING AND FEEDBACK

The concepts were discussed with and shown to Jonna from Fladbro Kro to get a customer point of view. [WS27]

BUNKER CONCEPT

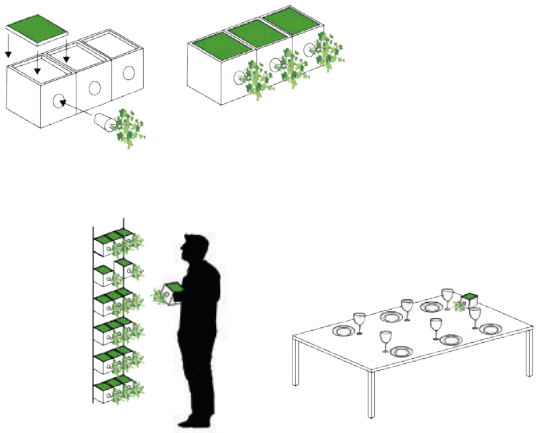
Outside placement would be a fine option. It will be a nice feature if it could be shown to the customers because of the added value. No need to dig it down in the ground. The proposal has to take sustainability into account by either being powered by solar cells or the materials. Towers will be a good way to grow because it minimises the concepts footprint. It is important that there is a way to control that you do not grow too many leafy greens and microgreens. Also it would be nice to have the opportunity to place it both outside and inside.



Ill. 42 - Use illustration for explanation of bunker concept

CUBE CONCEPT

The yield is not enough. The number of cubes will be too high and the time it will take to harvest and seed is too long. A wall with cubes will look good for customers but that is it. Jonna sees it more as a gimmick and a lot of restaurants have walls of greens because of aesthetics so it will not be as unique as she would like if it was placed in the dining hall.



Ill. 43 - Use illustration for explanation of cube concept

MODULAR CONCEPT

Modularity is a nice touch. The seasons requires a different amount of leafy greens and therefore modularity or the option to control how much you grow is needed.

GENERAL COMMENTS

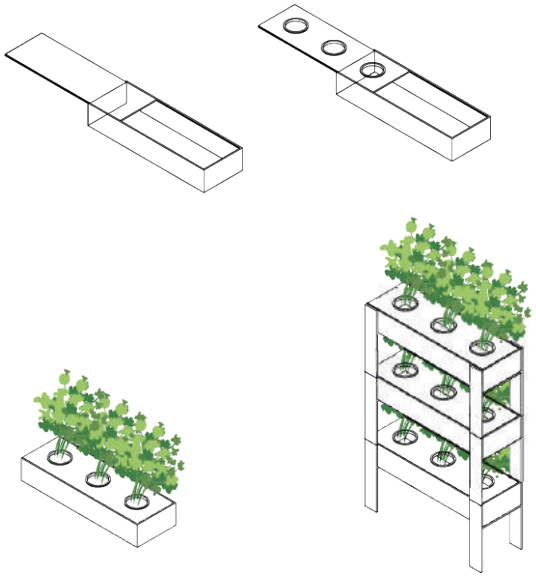
Leafy greens as the most important, herbs after and then microgreens.
System should fit into being harvested and put in condi buckets.

ADDED DESIGN DEMANDS

- Should offer modularity
- Be able to place both inside the kitchen/basement or at a dining patio

EVALUATION

The concepts need to fit the context and restaurants demands more. The amount produced is very important for them and the ability to change that.
The feedback gave a lot of ideas on how to progress from here and the next step is to re-understand the restaurants and challenges to get a larger picture of what the product proposal should do.



Ill. 44 - Use illustration for explanation of modular concept

Ill. 45 - Discover and define 2.0 introduction

DISCOVER AND DEFINE 2.0

After getting feedback from the target group the team realized that there were still a lot of different aspects of the limitations of the project that should be discovered and defined. Therefore a deeper understanding was sought through market and competitor analysis, technology analysis and context and defining different kinds of restaurants, ending out in additions to the design brief.

Chapters

- Defining restaurants
- Market and economy
- Competitor analysis
- Hydroponic technology analysis
- Context
- Updates to design brief

DEFINING RESTAURANT

Because of the ambiguous development of the concepts to grow leafy greens for restaurants the team decided to revisit what type of restaurants it is wanted to design too. This was done to get a clearer understanding of the restaurant types and what value they have in each segment. To get this understanding the team made a survey in order to evaluate the different restaurant types [WS25]. Based on this information the restaurants could be divided into different types.

An overview of restaurants which is associated with the different categories:

CATERING CENTERS AND FASTFOOD RESTAURANTS	CASUAL DINING AND CAFÉS
Local pizzaria Burger king	Café Vesterå Bones
FINE DINING	MICHELIN
Fladbro Kro Restaurant Rusk	Restaurant noma Restaurant Amass

Then the team could map out how the restaurants use leafy greens related to their customer segment.

The team typed out sentences to get a clear understanding of each cubicle found under "what do the restaurants expect of leafy greens".

Catering centers and fastfood restaurants: Leafy greens for fast food restaurants are to make the customer feel that the dish is healthier than it is. The customer pays for easy fast prepared food with the goal to get full.

Casual dining and cafés: The use of leafy greens in casual dining is for presentation and to give the customer a dish that looks more delicious. Most customers do not eat the whole salat though because the rest of the dish is large. The customer pays for a place to have quality time together with others while getting full.

Fine dining: In fine dining, the leafy greens are used to present the course and make it more visually appealing. Sometimes the leafy greens are the main component in the course which makes it even more important to secure the visual appearance and taste. The leafy greens are what "sells" the course. The customer pays for experiencing new food, taste and experience.

Michelin: At Michelin restaurants, the leafy greens are a part of both the story and the experience. The taste and freshness are very important for the restaurant and the customer. The Customer pays first for the experience and story, secondly the culinarian experience.

WHAT DO THE RESTAURANTS EXPECT OF LEAFY GREENS

CATERING CENTERS AND FASTFOOD RESTAURANTS		CASUAL DINING AND CAFÉS	
High quantity	Two kinds of leafy greens	Medium quantity	Four kinds of leafy greens
Reliable delivery	Visuals are not important	Reliable delivery	Visuals are down prioritized
Same type no matter what	Cheap	Non seasonal	Cheap
Will use imported greens	Pre-cut	Will use imported greens	
FINE DINING		**MICHELIN**	
Low quantity	Twelve kinds of leafy greens	Low - medium quantity	Twelve+ kind of leafy greens
Medium expensive	Visuals are important	Expensive	Everchanging menu
Forced to import greens	Reliable delivery	Local produce	Reliable delivery
Quality conscious	Seasonal menu	Quality conscious	Visual is essential

Then the team tried to find common needs according to leafy greens for each "box" even though every restaurant is different.

WHAT DO THE RESTAURANTS HAVE OF NEEDS ACCORDING TO LEAFY GREENS

CATERING CENTERS AND FASTFOOD RESTAURANTS		CASUAL DINING AND CAFÉS	
Quantity - 70 kg pr. week	Uncertainty in amount used	Quantity: 50-100 kg pr. week	1-2.5 hours stay
Preparing time is low	Low prices	"Ready to use"	Max 30 min pepare time
Pre-cut	Customer stay 10 minutes	Low price	Uncertain number of meals
Low quality	Max 15 min prepare time	Medium Quality	Non pre-cut
FINE DINING		**MICHELIN**	
High quality	Taste before apperance	Very high quality	3+ hours customer stay
Quantity: 4 kg pr. week	Consuming reparing time	High price	Fixed number of meals
Uncertain number og meals	1-3 hours customer stay	Engineering greens	Visuals are very important
High price	45 minuts preparing time	1 hour preparing time	Quantity: 4 kg pr. week
Fresh greens			

Here the team found different needs in each restaurant segment and based on that the team mapped out possible solution spaces and what solution would fit each segment.

WHAT COULD THE POSSIBLE SOLUTON SPACE BE IN EACH CASE?

CATERING CENTERS AND FASTFOOD RESTAURANTS		CASUAL DINING AND CAFÉS	
Mass production	Quality not important	Mass production	Continusly production
Cheap	Continusly production	"Ready to use"	Continusly harvest
"Ready to use"	Continusly harvest	Fast processing	Posibility for quality
Fast processing		Cheap	
Solution: Cheap, quick mass production.		Solution: Cheap quick mass production with possible quality.	
FINE DINING		**MICHELIN**	
Fresh	Easy harvest	Visual -> look alike	Accept higher price
Tasty	Time/planning is important	Taste and quality	Medium production
Medium production	Visual -> look pretty	Story telling	Time is not an issue
Option for various greens	Match curring price	Uniqueness	Option for various greens
Easy to manage and store	Story telling		
Solution: Quality production with easy manage and possibility for variation.		Solution: Engineered greens with high quality, visual presentable and telling a story.	

Four different solution spaces were found and with that, the team decided to focus on the fine dining aspect because of the access to restaurants and means with their own skills combined with the exiting solution space.

EVALUATION AND REFLECTION

It was clear that the fast food and casual dining was probably not willing to pay for a solution for locally grown vegetables as chosen for the project. The Michelin restaurant would need a highly engineering solution were the surroundings as water, light and nutrients would be the primary factor for this to happen. Also, the Michelin restaurants want uniqueness which is difficult to solve with one product.

Therefore it is chosen to work with fine dining restaurants who want to be conscious about where greens are from, the taste, visuals and freshness of these. They want a quality production with easy manage, time-saving, produces 4 kg per week, easy to store and does not take up to much space. The team now has a clear view of what solution space to focus on. Before continuing develop the the market, competitors, technology and context should be explored to not make the same mistake as previously.

MARKET AND ECONOMY

In order to understand how much money the restaurants are spending on leafy greens the team made an interview with the owner of Fladbro Kro to find out how the economy fits the problem. During the interview with Fladbro Kro, it was mentioned that the prices for a delivery was 1.000 DKK. This is an expense that is extra, so an addition to the price of the greens.
Fladbro Kro uses 4 kg. of greens per week and gets delivery 4 times a week. Assuming the delivery more times a week is because they want the leafy greens fresh, the delivery times will therefore probably go down if the leafy greens are not going to be delivered anymore.

To calculate the weekly amount of money used to purchase leafy greens from a supplier the prices from "Skive frugt" [Skivefrugt.dk] is used for calculation. The weight in the calculation also count the plastic which the greens are packed in, and it is with taxes. [WS30]

1 kg of felt salad	= 210	DKK
2 kg rucola	= 207	DKK
1 kg Spinach	= 107	DKK
4 kg of leafy greens	=524	DKK

The team estimates one delivery a week will be saved with a solution to the imported greens. Therefore the restaurant saves 1.000 DKK on delivery per week.

One week leafy greens will cost	= 1.524	DKK
One month will be	= 6.096	DKK
Which makes one year	= 73.152	DKK

EVALUATION AND REFLECTION

This calculation of the actual price of leafy greens gives the team an overview of the economical aspects of the problem. This also gives the first impression of the price level the solution could meet. These numbers are taken from Fladbro Kros supplier and based on how much supply they get. This can vary from restaurant to restaurant and could be researched more to get more reliable numbers.

COMPETITOR ANALYSIS

The business for having hydroponic setups to grow leafy greens at the site of consumption is booming. Different products are being developed and different business models are tried out in the community at the time. The team has gathered some of them to look at what the competitors can and can not do. [WS29]

The competitors will be evaluated on five parameters:
Price, amount produced a week, self-service level, type of leafy greens and modularity.
This evaluation will be both from a subjective point of view and what information is available online.

FARM SHELF

[Farmshelf.com]

Ill. 46 - Farm shelf for growing at the restaurants

Price	7.000$ + 105$ a month in subscription fees
Amount of leafy greens	Approx 4 kg a week
Self-service level	Manual seed and harvest
Type of leafy greens	>40
Modularity	Non

Competitive edge: Subscription-based delivery of seeds and nutrition.

CITYCROP
[Citycrop.io]

Ill. 47 - Citycrop for smaller indoor growing

Price	1.100 $ per unit
Amount of leafy greens	2,4 kg per 3 weeks
Self-service level	Manual seed and harvest
Type of leafy greens	>50
Modularity	Stackable

Competitive edge: stackable makes them more modular which gives more opportunities to fit in different contexts.

ZIPGROW RACK
[Zipgrow.com]

Ill. 48 - Zipgrow for indoor growing on limited space

Price	7.000$
Amount of leafy greens	7 kg in 3 weeks
Self-service level	Manual seed and harvest
Type of leafy greens	>50
Modularity	Amount of zipgrows decides how much

Competitive edge: moveable because of rag on wheels.

EVALUATION AND REFLECTION
Each of the competitors has an edge on another. The main focus is still in how much you can grow and not how easy it is to seed and harvest. Most products needs another product beside them for germination before the seedling is placed into the product. This could be an important competitive advantage for this project to look in to a solution which could do both in one.
This research was done through internet research and therefore a full description of the products cannot be reached but more an idea of how the products are working.

ADDED DESIGN DEMANDS
- Moveable
- Germination should be in the product proposal and not separate as today
- Should be able to be placed together to minimize space waste

HYDROPONIC TECHNOLOGY ANALYSIS

The purpose of this analysis is to understand the different hydroponic systems and potentially figure out what will be a fitting solution for restaurants.
Through internet research, the hydroponic systems will be investigated with a focus on space consumption and how automatic they are.

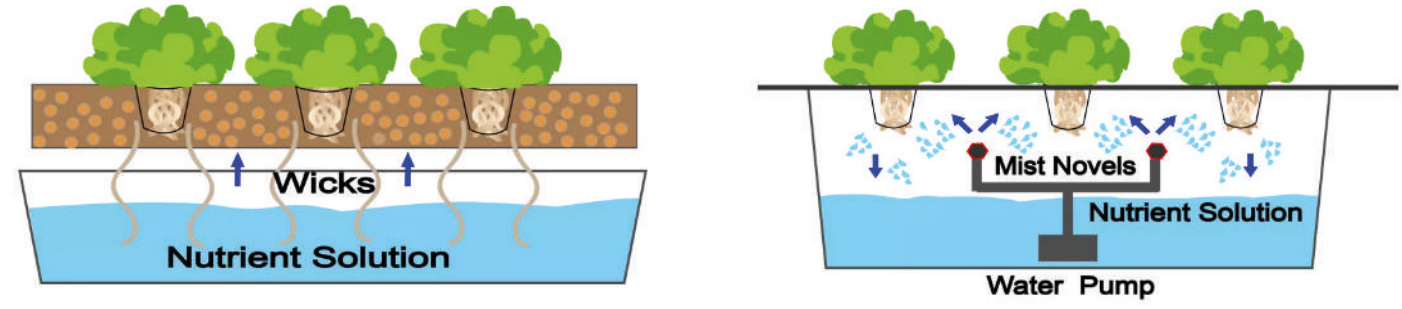
Six different hydroponic setups were chosen to investigate. They are described in [WS28]. In this chapter, four of them will be discussed. The four are; Deep water culture, Wick system, Drip system and Aeroponics. [no-soilsolution.com]

WICK SYSTEM

This is a very simple system where no electricity, pumps or air stones are needed. This system is the only one which does not need any electricity. The plants are placed in an absorbent grow medium using a nylon "wick" connecting the plants grow medium and the nutrient-rich water. This kind works best for herbs and small plants that do not need a lot of water because the nylon "wick" does not supply that much water to the plants.

AEROPONICS

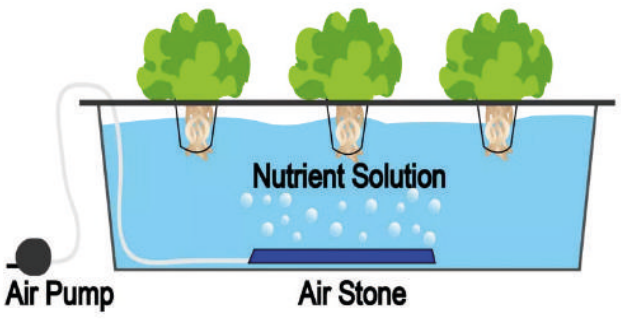
The roots in this method are in a closed box with highly humid air, so not solid water, but a cloud filled with nutrients by making mist from the water and "sprays" it on the roots. This system is not as easy as the others where the plants are supported in the air. The nutrition particles have to be small for easy absorption for the roots. It can grow all plants dependent on the setup.



Ill. 49 - Four different hydroponic systems

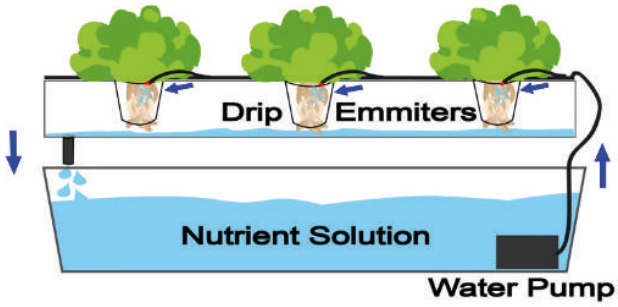
DEEP WATER CULTURE

Plants are placed in net pots with grow medium and the roots are placed directly in the nutrition-rich water which is constantly supplied with an air pump. This system is good for plants with large root systems.



DRIP SYSTEM

In this system, the nutrient-rich water is pumped up through tubes and drips water directly on the roots of the plants. And the extra water runs back into the water supply. The flow rate should be adjustable and can be used on all kinds of plants.



EVALUATION AND REFLECTION

This technology search was helpful in acquiring knowledge of different ways to grow leafy greens hydroponically. This research will help in the development phase to determine what system fits the context. It is still unclear on what light, pumps, nutrients and airflow will be the most optimal which is something that needs investigating later on. Next step from here is to implement these hydroponic systems into the development phase.

CONTEXT

In order to better understand the context, the team mapped and measured the possible placements opportunities at the restaurant, to determine if there were any limitations according to the proposals outer dimensions.

At Fladbro Kro two different places are considered as optimal places to integrate the product proposal according to both the team and the restaurant owner. This would either be outside at the terrace where they already have raised beds and have an opportunity to involve the customers in the harvest/seeding process, or inside in the kitchen under a table where it is close by where the food is prepared. [WS37]

In the context at Fladbro Kro, there is also a possibility that when the proposal is moved around it has to go over doorsteps and sometimes even up or down a staircase, but when the proposal is placed at one spot, it will probably be limited how often it is going to be moved that far. According to building regulations [Bygningsreglementet.dk] all level differences should be offset in terrain or by using a ramp, and doorsteps cannot be more than 2,5 cm tall. Therefore the assumption is that the proposal maximum should be able to be moved over an edge on 2,5 cm in height. It is observed in the context that no doorsteps are over 2,5 cm, regarding staircases it is not observed if they have a ramp for handling these according to the rules.

If the proposal is placed indoor it would preferably be places under the preparations tables. These are placed in a height of 90 cm over ground, and they are 50 cm deep. Measuring the unevenness of the ground surface outside, the slope is between 2 and 3 degrees when placed on garden tiles.

ADDED DESIGN DEMANDS

- Should be no more than 90 cm tall
- Should be no more than 50 cm deep
- Should be able to move over a 2,5 cm edge
- Should be able to move up and down stairs
- Should not be affected by being placed on a slightly uneven surface, 2-3 degrees

EVALUATION

At this point, the proposal should be considered to be placed both inside and outside. Inside is a demand, where outside would be nice to have. The information from this analysis will be used as design parameters to evaluate during development.

Ill. 50 - Outside is placed raised beds

Ill. 51 - Kitchen has multiple tables

Ill. 52 - Prep table is placed 90 cm over ground

UPDATES TO DESIGN BRIEF

PROJECT AIM
This project aims at designing a product proposal for fine dining restaurants who wants to use local food to ensure quality and delivery security and thereby not be dependent on imported leafy greens from southern Europe.

VISION
To make restaurants self-sufficient in leafy greens.

MISSION
Give restaurants the possibility to use locally produced leafy greens to match their needs for quality and delivery by growing the leafy greens at the restaurants.

TARGET GROUP
Primary user: Fine dining restaurants.
The fine dining restaurants are generally perceived as in the expensive end, the courses are cared for and are often small, but there is more courses. They try to differentiate from other restaurants by storytelling. Here more and more restaurants choose to use locally grown produces for all courses because this story is more appealing to the customers.

Secondary user: Customers at fine dining restaurants.
The customers that go to fine dining restaurants expect fresh tasty food, prepared and served as a pleasing culinarian experience both visual and tasty in a new way. They pay for both the food, but also the story and the thoughts behind the restaurants concept.

CONTEXT
In the context, the product proposal can be placed either in the kitchen under preparation tables or outside on a terrace. The product proposal should not be more than 90 cm tall and 50 cm deep to fit under the kitchen table. It should be able to move over 2,5 cm tall edges and the product proposal should either be adjustable or not be affected by placement on uneven surfaces.

BUSINESS
When acquiring greens the restaurant gets delivered vegetables 4 times a week for a delivery price on 1.000 DKK per delivery. By growing the leafy greens at the restaurant, they would not need to get delivery that often and could probably save 1.000 DKK a week on a delivery fee if the leafy greens were not delivered. They use 4 kg leafy greens per week which is estimated to 524 DKK. The weekly amount spent on acquiring only leafy greens is therefore 1.517 DKK, One month will be 6.096 DKK, Which makes one year 73.152 DKK. This gives an economical idea for the price of the product proposal.

DELIMITATIONS
- For vegetables, the team is only going to focus on growing leafy greens.
- The project limits from specifying light source and kind of nutrients because this is still under development and there is no specific source to determine what kind is best for growing hydroponically.
- The project does not consider the larger sustainable and environmental aspects of the solution.
- The project does not want to compete with locally produced vegetables and vegetables found in the forest.

DEFINED DESIGN DEMANDS
- Movable
- Should be no more than 90 cm tall
- Should be no more than 50 cm deep
- Should be able to move over a 2,5 cm edge
- Should not be affected by being placed on a slightly uneven surface 2-3 degrees

ILL-DEFINED DESIGN DEMANDS
- Should offer modularity
- Be able to place both inside the kitchen/basement or at a dining patio
- Germination should be in the product proposal and not separate as today
- Should be able to be placed together to minimize space waste
- Should be able to move up and down stairs

DESELECTED DESIGN DEMANDS
- Should grow microgreens

Ill. 53 - Deliver 2.0 introduction

DEVELOP 2.0

With the new found knowledge the team went back to development. The concepts from the last develop phase were evaluated, changed and tested. One concept was chosen and developed in depth with all needed aspects in different sketching rounds with the purpose of ending out in a more concept. Thereafter a explorative dive into the most critical parts of the concept was conducted to detail the concept and turn it into a product proposal.

Chapters

- Evaluate concepts
- Mock-up and testing
- Board, methaphors and feeling
- Develop the seeding process
- Develop the tower
- User scenario for sketching
- Tjalve systematic sketching
- Sketch pool on parameters
- Sketching on subcategories
- Combine to one concept
- Explorative dive
- From concept to Acetarium

EVALUATE CONCEPTS

This ideation was done using mock-ups. The initial ideas were the same as from the initial ideation and muck-up testing, but they had to be specified more to make a valid selection of which concept to work with further.

Before beginning this mock-up ideation some conditions and technical limitations were investigated to make sure the concepts were developed in the right size, with space for all the necessary components. These are listed in [WS33]. A hydroponic system needs; grow medium, grow medium holder, water pump and watering system, water tank, LED grow light, climate control and nutrients. The distance between light and plants should be 20 cm and the distance between the plants should be 10 cm. Each plant needs approximately 0,66 L water per week.

To develop a more specific concept and choose one to develop further on, the team dismissed the CUBE concept because of the feedback from Fladbro Kro. The "Bunker" and "Modular" concepts was chosen for further develop. The concepts were built as mock-ups with the technical limitations in mind and tested in different user situations to choose the best one according to the context where it is going to be used [WS32].

The mock-ups were hereafter evaluated, by using act it out, to get a understanding of how the concepts would work if placed and used in different situations.

MODULAR CONCEPT

The modular concept was made to have trays inside a sealed container providing water, light and air to give the optimal grow conditions. The trays are made to be taken out easily and harvested or placed on the prep table for the chef to cut off the needed leafy greens. The seeding is easy where you place a plug with a seed in to the tray to start the growing process.

The modular concept was therefore placed on a table, under a table, on a wall where also mobility and interaction with trays were considered.

Placed on table: The concept was to deep to be placed on a kitchen table, this could be solved by making it shorter, but thinking about the context the table space in the kitchen is crucial for the chef and therefore the table placement is probably not an optimal solution.

Under table: Placed under the table the concept would not be in the way but it would be hard to interact with because it is so far down. Even if there was stacked more on top of each other the one at the floor would be unhandy to handle.

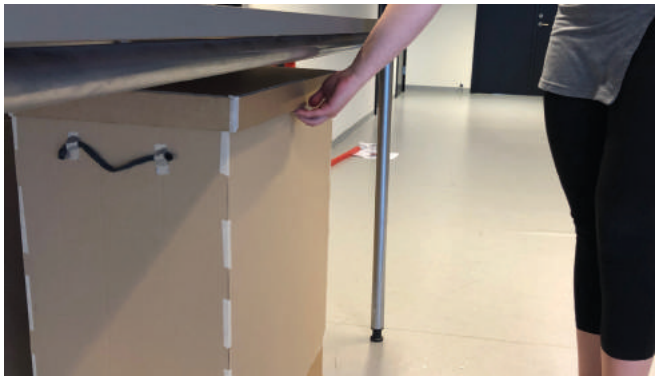
Ill. 54 - Modular concept on table

Ill. 55 - Modular concept under table

Ill. 56 - Modular concept mobility

Mobility: When moving the concept it is not larger than it would be carried around but with a 20L water tank, if the tank was full, it would be to heavy.

Ill. 57 - Bunker concept as side table



Ill. 58 - Bunker concept under table

Ill. 59 - Modular concept mobility

BUNKER CONCEPT

The bunker concept was made smaller due to requirements from [WS33] about distance of light to plant and size of light. Also the amount of salad grown in one box was considered and it was chosen to grow approximately 4 kg. in one box due to the fact that the restaurant interviewed uses around 4 kg of imported greens per week.

The bunker concept was placed next to a table and under a kitchen table, the interaction with towers was considered a long with the mobility of the concept.

Next to table: The concept could be used as a side table to be used by the waiters when they serve food. There is a opportunity to integrate the proposal into the dining situation but there might be a problem if something is standing on top and the chef needs to harvest.

Under table: The dimensions fit under the preparation tables in the kitchen. In the kitchen it is close to where the chef will use the leafy greens and by storing it under the table it will save space.

Mobility: For moving the box there would need to be some kind of handle on the end of the box and some wheels or a moving tool. The proposal would be to large to carry or move without wheels or a additional tool.

EVALUATION

The bunker concept was chosen for further development. The modular was evaluated harder to implement in the context, where the bunker did not seem like it would be in the way.

REFLECTION

There is still a lot of development left on the concept. The concept should be broken down into use scenarios and developed on with different views. For instance the seeding, maintaining, feedback, harvest, use and so on could be scenarios to develop on and then assemble a better functional product proposal in the end. A styleboard or interaction board could also be helpful to develop from, so the feeling and looks of the proposal is considered already at this point.

MOCK-UP AND TESTING

After choosing a concept to work further with, the team went out in the field to get feedback and pinpoint critical elements of the use, interaction and context placement. Simultaneously the team investigated different grow mediums and how much attention growing leafy greens hydroponically would take.

MOCK-UP TEST

The team went out into the context to discuss and test the concept. First the mock-up was placed in different contexts both in the kitchen and outside on a terrace. Here it was discovered that the concept could be placed under worktables along the wall because of the depth of the worktables. Next up was outside at the terrace. Here the team and owner of the restaurant discussed if the product proposal should be next too tables to function as an extra small serving table or be hidden away together with pillows for the chairs. The concept would be outside only in summer time and moved inside during the "wet" seasons.

Along with the context, the interaction was discussed with mock-ups of the towers. Here the owner talked about the trust in placing a seed. How reliable will it be? Would she feel safe when inserting the tower in to the grow box and not look again if she placed the seeds correct? The feedback in the product proposal was discussed where automation level was the main point. The owner would look into the box a lot until trust is build but did not feel a need to get a notification about if the leafy greens were as they should, but only if there was an error in the system or something was critically wrong. An example could be water level in tank or if the water system was blocked.

There should be an opportunity to both harvest and seed all at once or harvest when needed. Therefore the concept has to take into consideration how much leafy greens a day are used and how much a week worths of greens are. To read about the whole mock-up test see [WS39].

EVALUATION AND REFLECTION

The test gave a lot of insights in where in the context the restaurant would like to place the product proposal. What type of feedback the team should strive to achieve and seeding interaction. The next step is to dig deeper into these aspects and test how it could be designed according to the design demands.

ADDED DESIGN DEMANDS

- One product proposal should produce 1 weeks worth of leafy greens
- Opportunity for day to day harvest
- Feedback as a tool to get critical information

Ill. 60 - Outside on the terase

Ill. 61 - Inside under the prep table

Ill. 62 - Inside under another table

GROW MEDIUM INVESTIGATION AND GROW EXPERIMENT

The team wanted to investigate aspects of growing leafy greens on their own and what different types of grow mediums are sufficient for the concept as it is now.

First the team investigated different grow mediums and what they offer. All grow mediums investigated can be seen in [WS34].

Ill. 63 - Coco coir

Coco coir
- Hormone rich
- Strong germination
- Good water and air ratio

Ill. 64 - Rockwool

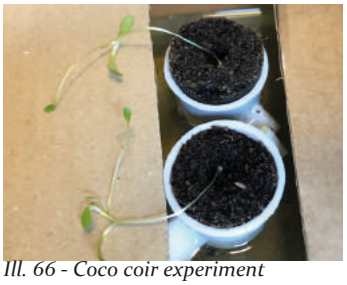
Rockwool
- Great air and water ratio
- Cheap
- Hard to clean

Ill. 65 - Zipgrow matrix media

Zipgrow matrix media
- Great air and water ratio
- Reusable
- Easy to clean
- Flexible

To validate them the team set up some experiments to see how they work and what composition of grow mediums should be implemented into the concept. These experiment are described further in [WS38].

Coco coir
- As medium
- Nutrient in medium
- Need extra medium for roots
- At day 6

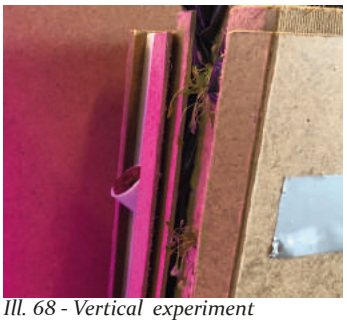


Ill. 66 - Coco coir experiment

Rockwool
- As plug and no medium.
- Need medium for roots.
- At day 21

Ill. 67 -Rockwool experiment

Rockwool vertical
- Hard to get nutrients to reach medium.
- At day 10.



Ill. 68 - Vertical experiment

ADDED DESIGN DEMANDS

- Plug should have nutrients in
- Grow medium should allow water flow and air flow
- Grow medium needs to be kept wet

EVALUATION AND REFLECTION

Growing leafy greens does not require a lot of maintenance other than water and light. Seeding requires a lot of precision and therefore the medium should help the user seeding.
Nutrients are hard to get up to the seed in the beginning and therefore medium with nutrients would be a fine tool to help the user growing. When growing leafy greens it should be in a controlled environment to ensure optimal grow conditions which was not obtained during these experiments.

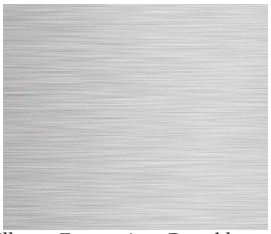
BOARD, METAPHORS AND FEELING

To align the team members presumption of how the style, technology, function and use of the product proposal should be, an expression board, metaphors for use and interaction and lastly how complex the product proposal is wished to be in the final proposal was defined. [WS36]

The team made a board for expression, color and aesthetics for inspiration and possible demands.

The styleboard gave the team a ground for decisions about the outer expression of the proposal where simplicity would be the main focus.

Ill. 69 - Expression: Simple on the outside



Ill. 71 - Expression: Durable

Ill. 70 - Expression: Rounded edges

Ill. 72- Expression: One piece

Ill. 73 - Expression: Strict curves

Ill. 74 - Colors in black/gray

Thereafter metaphors were used to describe the desired use, feeling and function according to lid, tower, seeding and feedback so the interaction feeling of the product proposal is thought into the ideation later.

Metaphors were made for giving a more pictorial and relatable idea of how the product proposal is wished to feel when it is in use.

Ill. 75 - A liter of milk

TAKING UP GROWTOWER

Gives the feeling of picking up one liter of milk in the supermarket

Ill. 76 - Golfball on a tee

PLANTING THE SEEDS

Gives the feeling of placing a golfball on a tee, ready to drive.

Ill. 77 - Toilet seat

CLOSING THE LID

Gives the feeling of letting go of a toilet seat, without smacking down.

Ill. 78 - App on phone

GETTING FEEDBACK ON YOUR PLANTS

Gives the feeling of checking the health app on your smartphone.

Last making parameters on how automatic the system should be according to watering, climate and light, to set some constraints to evaluate the future ideas on.

For the complexity of the system the water system, ventilation and lights was measured on a scale from simple to complex to use as design demands for further development.

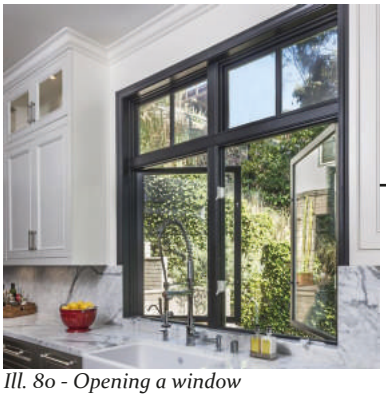
WATERING SYSTEM

Ill. 79 - Hand watering

The product proposal should be automatic watering but the water tank needs filling once in a while.

Ill. 82 -Automatic sprinklers

VENTILATION



Ill. 80 - Opening a window

The product proposal should have an automatic ventilation system with adjustable heat.

Ill. 83 - Using air-condition

LIGHTS

Ill. 81 - Energy from the sun

The product proposal should have a light with timecontrol and be connected to a power outlet.

Ill. 84 - Using focused sensors

ADDED DESIGN DEMANDS

- Proposal expression should be simple, dark colors and defined strict shapes
- Automatic ventilation system
- Semi-automatic watering system
- Time controlled light
- Lightweight tower
- Seeding in one motion
- The lid should close softly

EVALUATION AND REFLECTION

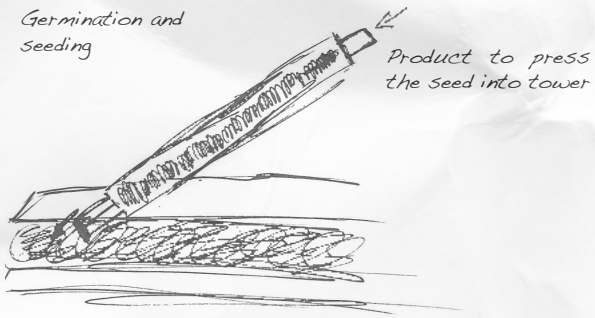
This gave a common direction and some relatable goals to achieve in the development of the product proposal and a guideline for the team to follow to get a product proposal where the team agrees on how it should look and how it should feel to use.

The hope is to achieve a smooth development process according to these “soft” factors so that there will be less discussion and more action in the last part of the development phase. The metaphors explaining different interaction was not done on every interaction aspect on the product proposal. This could have been done to make ideation more aligned.

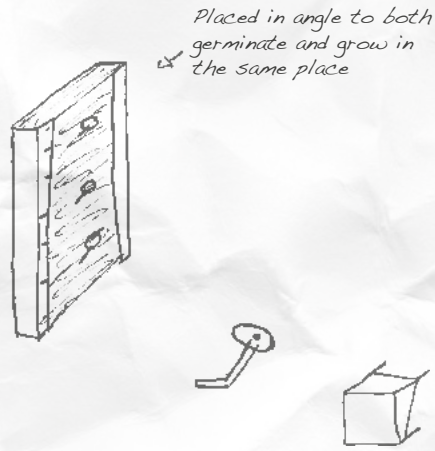
DEVELOP THE SEEDING PROCESS

The purpose of this chapter is to develop the seeding process to be easy and trustworthy for the user.

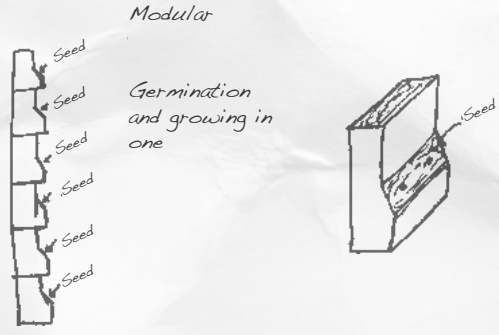
The team started out with a sketching round to get ideas for the seeding process that could be iterated on and developed on. The team had the metaphor from earlier to use as a guide for the sketches. The metaphor was; “Like putting a golf ball on a tee” The team had earlier realized that a mix of germination and growing situation would be a preferable solution so the user could save a workflow. To read more on this development process see [WS40].



Ill. 85 - Sketch tool to “shoot” seed in grow medium



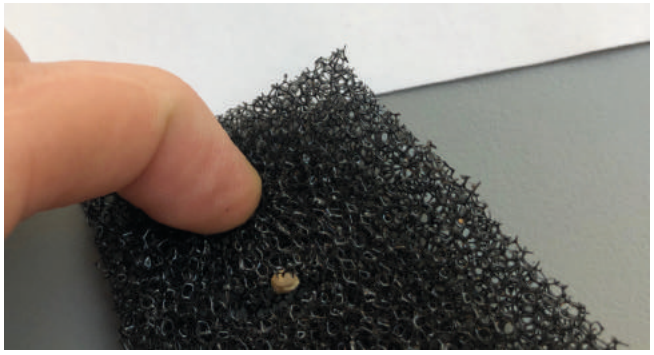
Ill. 86 - Nail to place seed at grow medium



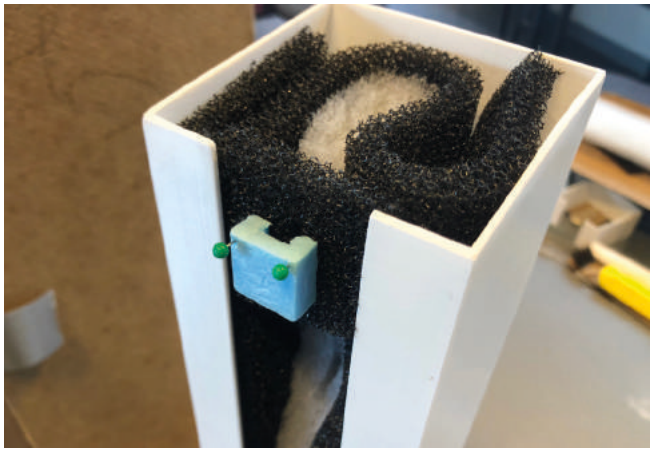
Ill. 87 - Modular system with a base for seeds

These sketches were made into quick and dirty mock-ups to evaluate on the principles.

The team decided not to work further with the principle where the seed is placed directly into the plastic grow medium because during a test it was not possible to get the seeds to germinate inside the grow medium. The medium is better for handling roots and not germination.



Ill. 88 - Seed into plastic grow medium



Ill. 89 - Seed “rack” into grow medium

Ill. 90 - Plug as nail for seed

Therefore a mixture of the nail princip and rack was developed.

Here the team tested two angles to hold the seed and plug, 30 and 45 degrees. The team found that the 45 degrees was most reliable after test with seed into coco coir plugs. There should be a groove into the coco coir plug to place the seed because of security. Even though the seed sticks to the plug when it's wet, the groove is needed when placing the tower into the box.

Ill. 91 - Plug holders with two different anglings

The last thing to investigate is how much the plug will expand when it gets wet. The plug holder should be designed after these dimensions.

As seen on (ill. 92) the coco coir plug expands to fill out the plug holder when it gets wet. In that way it gets fastened into the plug so it is difficult to remove.

Ill. 92 - Test to see if the plugs fits in the plugholder

EVALUATION AND REFLECTION

The focus on this part was to integrate the germination into the towers. To make this easy the team developed a seeding scenario where the seed will be angled 45 degrees into the tower instead of the 90 degrees that are normal. This together with the wet coco coir plug will hold the seed in its place when placing the tower into the box and when the plug holder with plug and seed are placed into the tower.

The next step is to develop the tower with the seeding in mind to see if the team needs to go back and develop on the plug holder again for the plug and tower system to fit together.

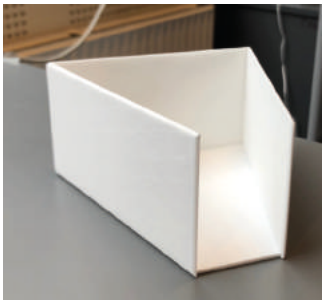
DEVELOP THE TOWER

The tower was developed further. Size, form, interaction with plug, seed, grow medium are explored and integrated into each other.

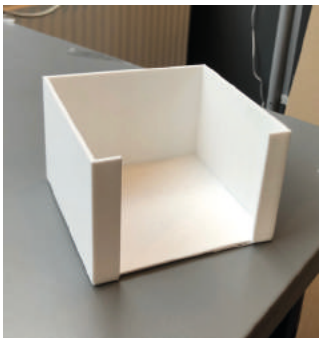
At first the size was considered. The goal is to provide 4kg per product proposal. This means that each of the 6 towers should provide 0,66 kg of greens to the restaurant per three weeks. Each leafy green weighs approximately 125g after 3 weeks, which means that the product proposal should grow at least 32 leafy greens plants.
Therefore it was decided to have 6 leafy green plants per tower. A total of 4,5 kg leafy greens for one box. Each plant needs 10 cm space to grow properly between each other. This makes every tower 60 cm in hight.
From the visit to nabofarm the dimensions on grow towers is known to be approximately 9,5 cm x 9,5 cm.

With this knowledge it was decided to develop different shapes to test out according to the mock-up of the product proposal space wastement. The grow mediums standard size was also taken into consideration. For the whole experiment see [WS48].

Ill. 93 - Round form wastes space. Does not proper fit the grow medium shape.



Ill. 94 - Triangular wastes space on the sides. Need to cut grow medium to fit.



Ill. 95 - No waste of space. Same size as grow medium.

Based on the evaluation of the different shapes according to space efficiency, it was chosen to work further with the square tower form.

Next step for the team was to look into how the tower would feel like in the hands of the user.
Models with different edges was made to find a form suitable for handling.

Ill. 96 - Testing how the tower feels in the hand with test person 1

Ill. 97 - Testing how the tower feels in the hand with test person 2

Here the result was an edge of radius 20 mm based on the test persons feedback [WS48].

After this part of the experiment the team stopped and looked on what were missing. It were discovered that interaction between plug and tower was missing as well as production, scalability and how algae form in growing mediums. Therefore the team went back and ideated on the tower again. To see the whole process see [WS51].

To develop the tower again firstly the interaction between plug and tower was investigated.

Features such as inserting it in the grow medium and placing it in the right distance to each other was discovered.

To develop the tower again firstly the interaction between plug and tower was investigated.

Features such as inserting it in the grow medium and placing it in the right distance to each other was discovered.

Ill. 98 - First insert it into the grow medium

Ill. 99 - Thereafter twist the plug holder to make it stay in place between the grow medium and tower.

Then the team considered how it can be placed right every time.

Ill. 100 - Distance markers on the tower which helps placeing the plug holder in the right distance every time.

Here visual communication in the tower and on the plug holder were developed. With this the user knows where to place it everytime and does not have to worry about if there is enough space between the leafy greens.

The next step is to look into forming of algae in the towers. When wet grow media is exposed to light algae is formed over time. This will not be acceptable in a kitchen and therefore algae should not form. A new form was developed for the tower and discussed. both in production, scalability and seeding process.

Ill. 101 - Investigating how to handle algea growth

If the product proposal should be scalable later to a new market such as strawberry or herbs the spacing between plugs should be considered as the place to make it modular. The two different tower forms in (ill. 101) was therefore discussed with production in mind for the scalability and together with development on the plug holder the team came up with a new form for the plug holder to make it scalable.

Ill. 102 - Plug holder with a sheet that can block light and avoid algea growth.

Here the plug holder was redesigned to instead of having arms to place it with, it was now a sheet at 10 cm to keep the plants 10 cm apart. This sheet will block the light. The insertion will be from the top and placed down dividing the grow medium. If the product proposal should grow strawberries or herbs a sheet with no plug holder would be placed between two plug holders to create the desired space between the greens.

EVALUATION AND REFLECTION

The towers together with the plug holder now blocks algae and can be scaled with the interaction in the plug holders. The plug holders form helps the user interact with them and place them correct every time.
The next step is to dig deeper into the towers and plug holder interaction together with the rest of the product proposal.

USER SCENARIO FOR SKETCHING

To understand all the situations where the product proposal is going to be in use or interacted with a scenario overview with notes of what should be considered when developing further. The team discussed all the possible scenarios of using the product proposal. A "scenario" walkthrough was made in text where all user situations were unfolded by making an overview of essential decisions and considerations that should be made and what challenges within the scenarios there should be solved. This should create a starting point for the next ideation and development phase.

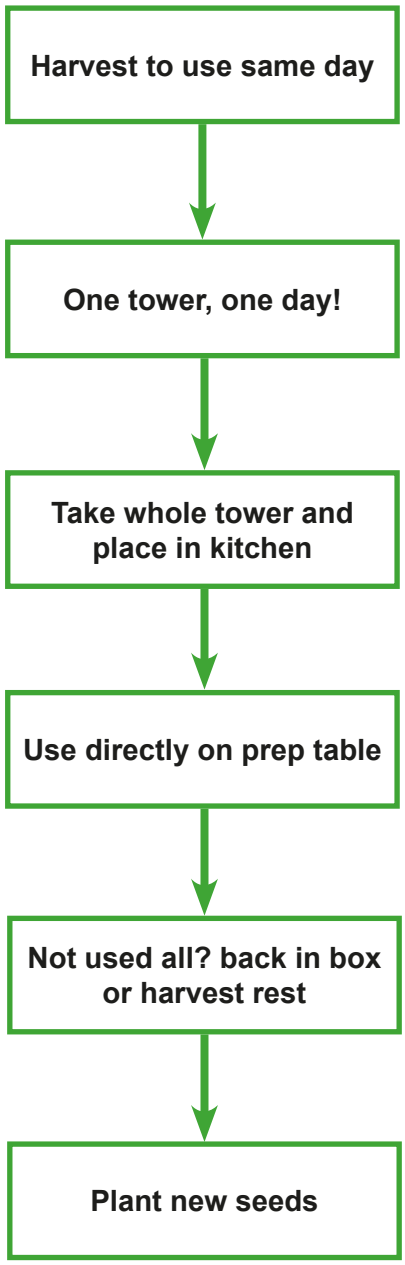
The scenarios were divided into; receiving product & seeding, grow situation, harvest scenario(Ill. 103), first time use & maintenance and other general considerations. See [WS49]for all scenarios.

EVALUATION AND REFLECTION

This gave a focus for further development. At this point the scenarios where the product proposal should be interacted with was laid out and the next development step would be more focused. It gave an overview of things that had not been considered yet, but should be considered in further development and a deeper understanding of the use situations.
The team was using this to align expectations and thoughts to make a more focused further development. The scenarios will be used to make a list of parameters to sketch on individually.

THE CONSIDERATIONS REGARDING THIS SCENARIO

- Will excess water run out of tower?
- Can the handle on the tower be used as holder?
- Should the leafy greens be stored cold?



Ill. 103 - Harvest scenario 2

TJALVE SYSTEMATIC SKETCHING

The concept was still rather undefined and the team decided to use Tjalves methodology [Tjalve, E. 1976] to challenge the placement of components, the form of the towers and the shape of the box to draw systematically and make considered choices on form and placement of the elements.

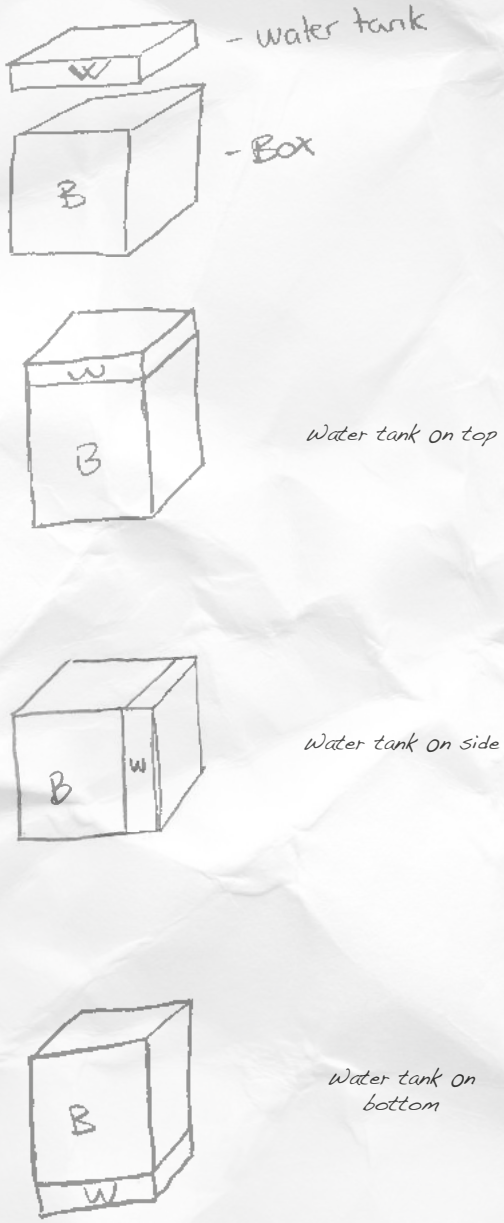
Form, light placement, water system, tank placement, tower placement and soon on were sketched on individually and then rated if it would work or not. If the constellation would work, the parameters was combined one at a time until one constellation was left. See [WS53] for all drawings.

EVALUATION

The optimal placement of the water tank is beneath the box, the optimal shape of the tower according to placement in boxes is either triangle or square. The light placement rule out the triangular shape of the towers. On the box shape considerations, the only optimal one for both watering, lighting and tower placement was the square. Placing the towers in the middle of the box is the more optimal of the two options left, because placing the towers in one side will make the product proposal side heavy and maybe make it tilt over when moved. Therefore the optimal constellation of the product proposal is a square box with square towers placed in the middle.

REFLECTION

This gave a challenged sight on if the original placement of the components was optimal. It seemed as the original thoughts were the most logic placement of the towers, light and water for most optimal use. Tjalve is a narrow minded way to look at a product proposal and therefore might not be so trustworthy in the results from a design point of view because it is very black and white. But on the other hand it is a tool where different compositions of a concept can be tried out very quick and therefore unlogical constellations of components will not be spend time on. Next step is to use the scenarios to sketch on parameters for the product proposal with the component placement found in this experiment in mind.



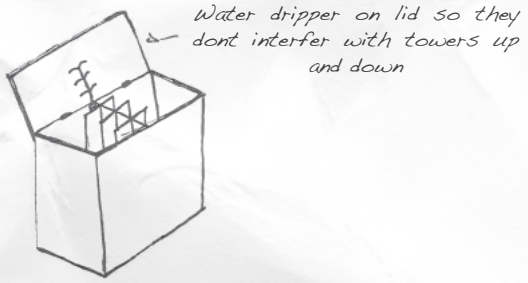
Ill. 104 - Tjalve to determine the placement of the water tank

SKETCH POOL ON PARAMETERS

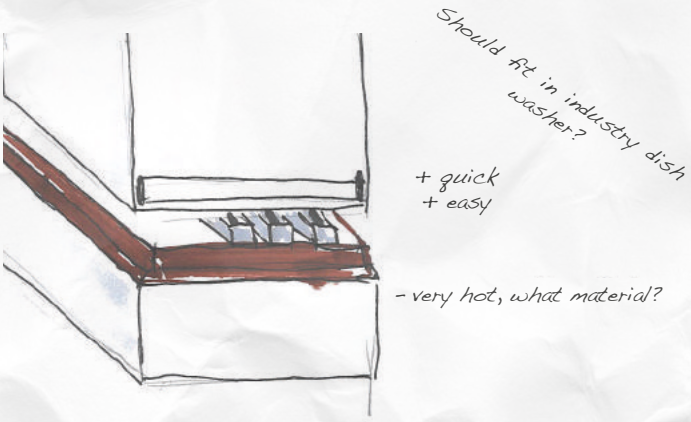
The team realized that a lot of time had been used on discussing instead of documenting and sketching on ideas for solutions to challenges in the product proposal according to scenarios. The discussing of different solutions was not documented and it was difficult to keep track of, if all the challenges were solved and how they affect each other. Therefore it was chosen to make a sketching round on known parameters which should be developed further at this point of the project. The goal was to understand the components needed individually and how they should be used in collaboration with each other using likely scenarios. See [WS54] for all sketches.

The parameters chosen to focus on from the scenarios:

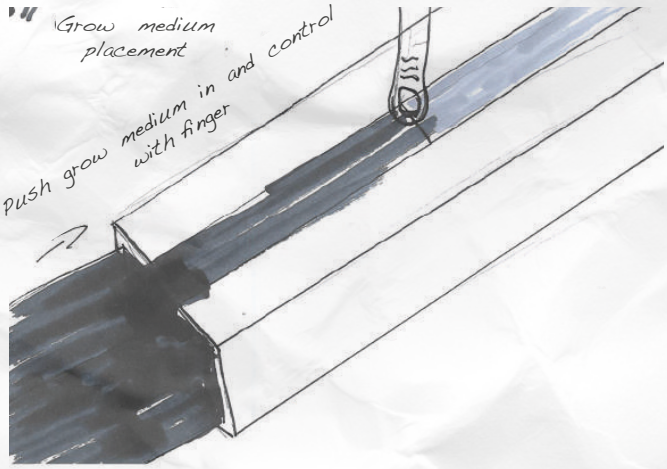
- Fit in context
- Prepare a tower
- Insert and take out tower from box
- Moving of box
- Tower at prep table
- Cleaning
- Watering
- Feedback
- Harvest opportunities
- Placement of light air and water
- Collect water back in tank



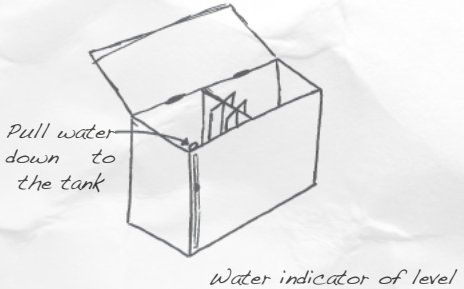
Ill. 106 - Watering system placed in the lid



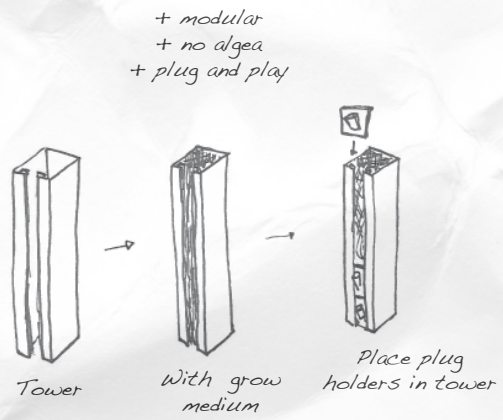
Ill. 107 - Cleaning the towers in dish washer



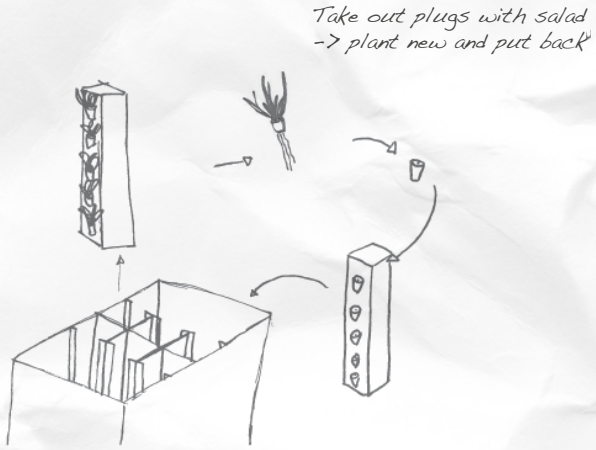
Ill. 105 - Prep the tower by placint the grow medium



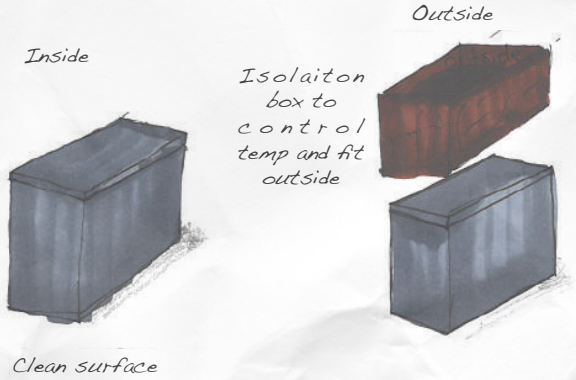
Ill. 108 - Fill water into tank by tube



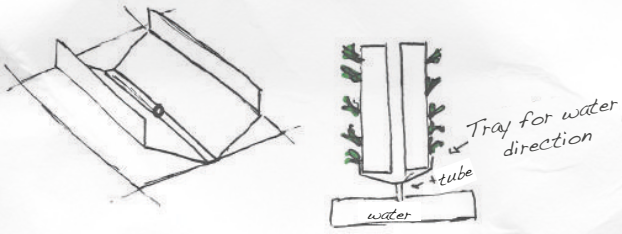
Ill. 109 - Prep the tower by placint the plugholder and plug in the tower



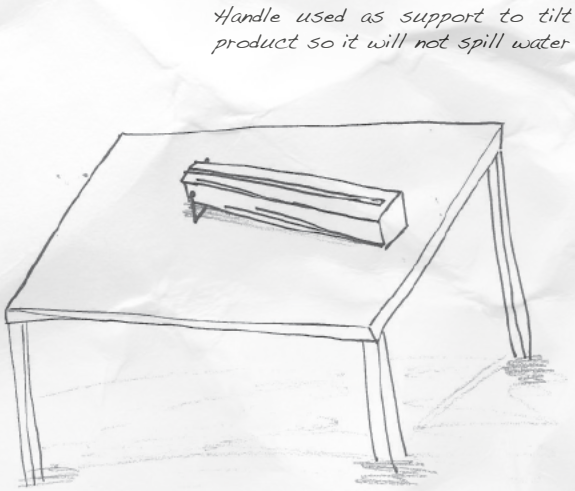
Ill. 112 - Harvest opportunity by harvest and seed in one workflow



Ill. 110 - Fit in context by having a cover for outside



Ill. 113 - Collect water back in tank by using tray in bottom



Ill. 111 -Tower at prep table by using a handle as support

EVALUATION AND REFLECTION

All sketches were discussed in the team and either chosen or not chosen for further development by using the design demands for evaluation. All sketches that had a quality that could be used were chosen for implementation in a product proposal. It was chosen to draw further on the parameters. But before further development the sketches were divided into 6 sub categories for the parameters that should have a connection with each other as a whole “system”.

SKETCHING ON SUBCATEGORIES

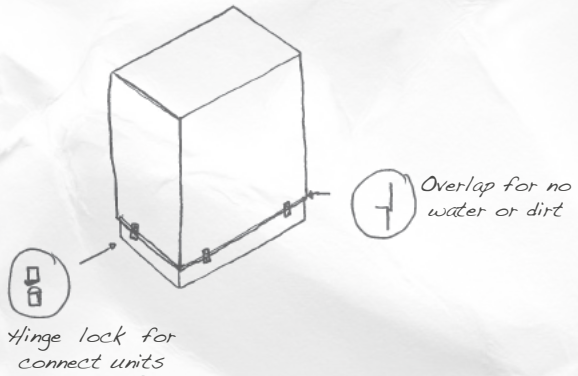
As a result of the parametric sketching round there were some commonalities within some of the sketches. That led to dividing the sketches into subcategories which would be developed on as a whole "system" or object with focus on interaction and challenges within the subcategories.

Subcategories:

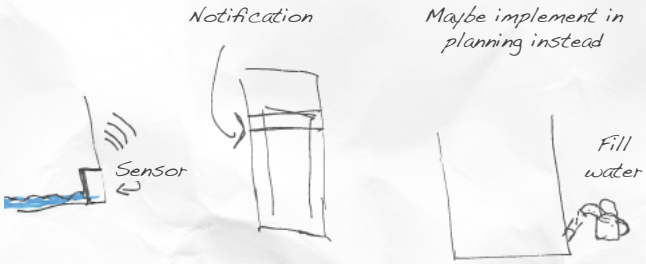
1. Fit in context + moving around
2. Water fill-up + Cleaning
3. Prepare grow tower and tower placement
4. Component placement of light, air and water
5. Collect water + Watering system
6. Feedback

Before sketching on each category the essential challenges within each category were unfolded [WS55].
Here the challenges again focused on interaction and scenarios of use within the individual subcategories and the team sketched on the different challenges.

These sketches were also rated useful or not with pros and cons for each individual idea. The ones shown in the report are all voted useful to some extent according to the design demands.

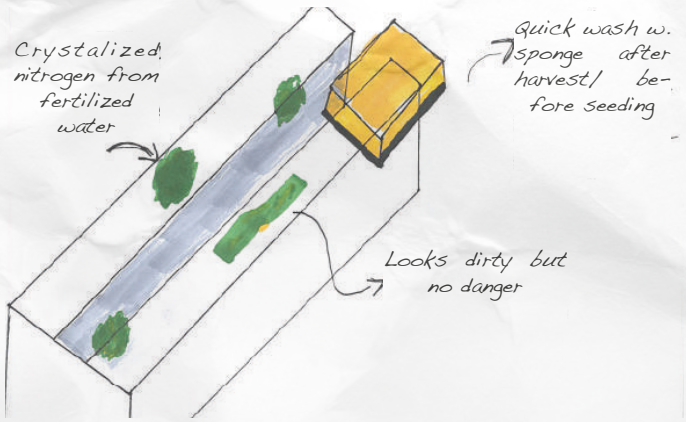


Ill. 115 - Hinges used to connect units so it is movable

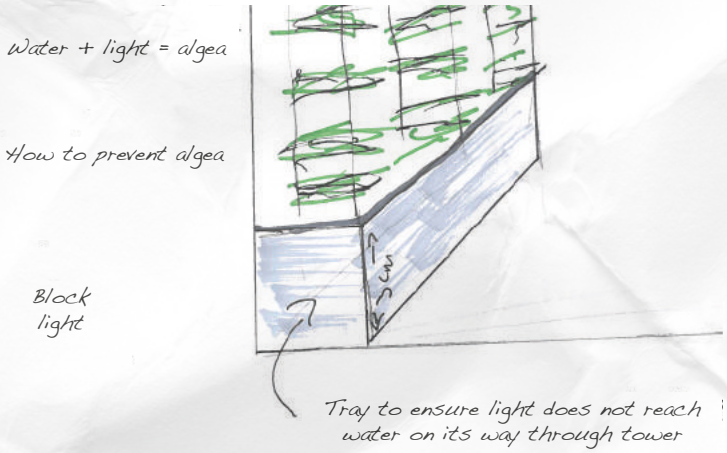


Ill. 116 - Sensor to know when to fill water on tank

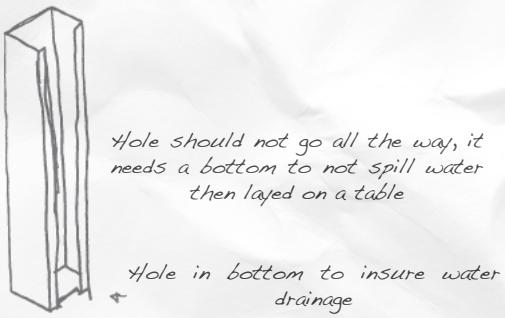
Ill. 114 - Wheels and handle to move around



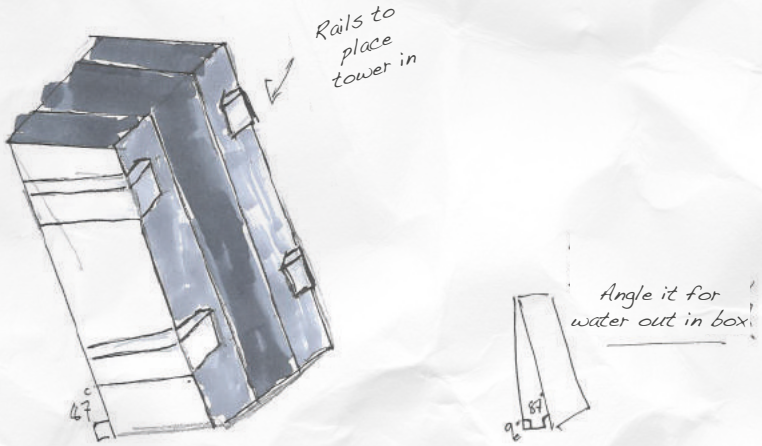
Ill. 117 - Cleaning the towers with a sponge



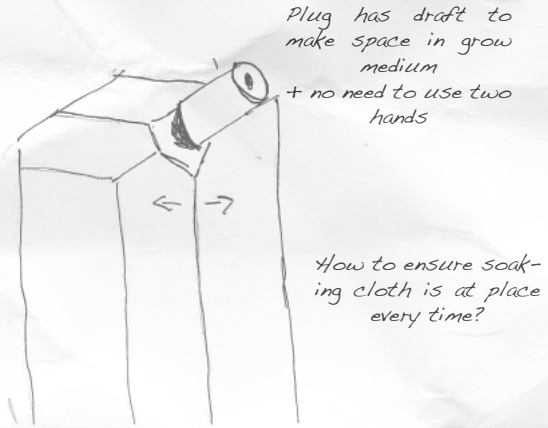
Ill. 118 - Block light when it drips down to prevent algea growth



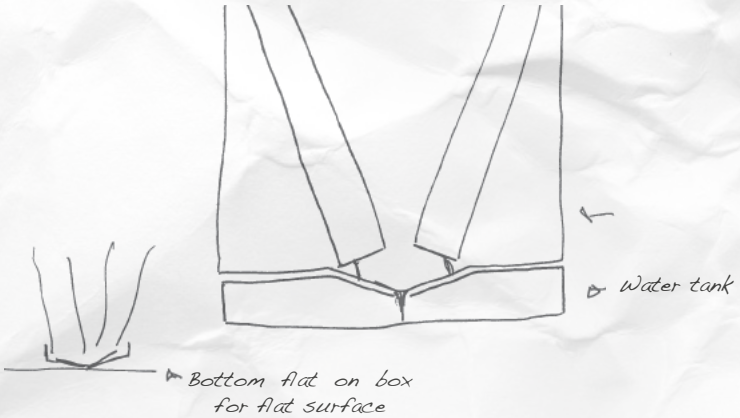
Ill. 121 - Making a hole in bottom of tower to drain water



Ill. 119 - Rails to place tower in so it is secured when moved



Ill. 122 - Plug with a peak to insert between grow medium and soaking cloth



Ill. 120 - Angle in bottom to help water back into tank

EVALUATION

After sketching on the different challenges the sketches were discussed, and evaluated in how useful the idea was and what pros and cons it had. The ideas are still very "one single function" oriented and there are no full solutions yet. But with the parameters it will be possible to collect all the chosen drawings and merge them into a full solution.

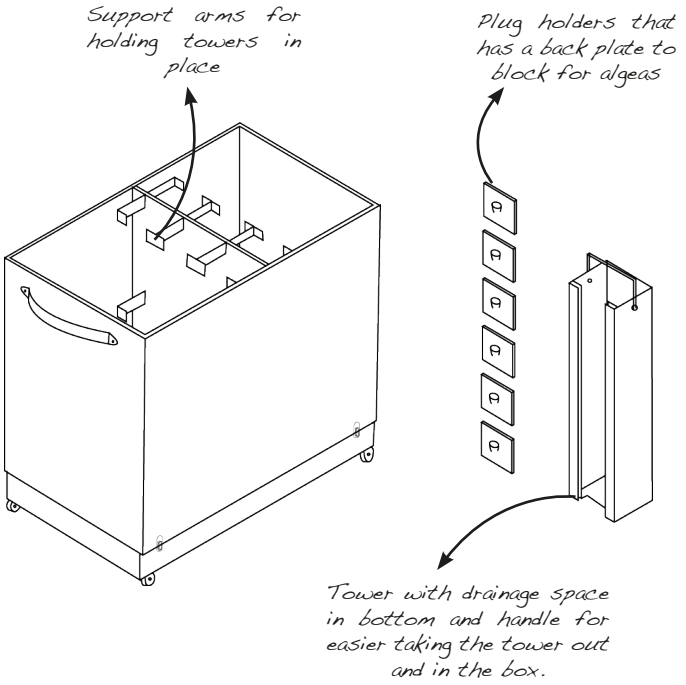
REFLECTION

The team has now sketched on different aspects and chosen the ones who are fit for the product proposal. Now is the time to combine and evaluate on the whole solution and see new challenges in the product proposal design to solve. Even though it could be minor challenges the team could maybe have avoided this by combining more frequently in the process earlier to see if they missed a vital design challenge when all scenarios have to fit together.

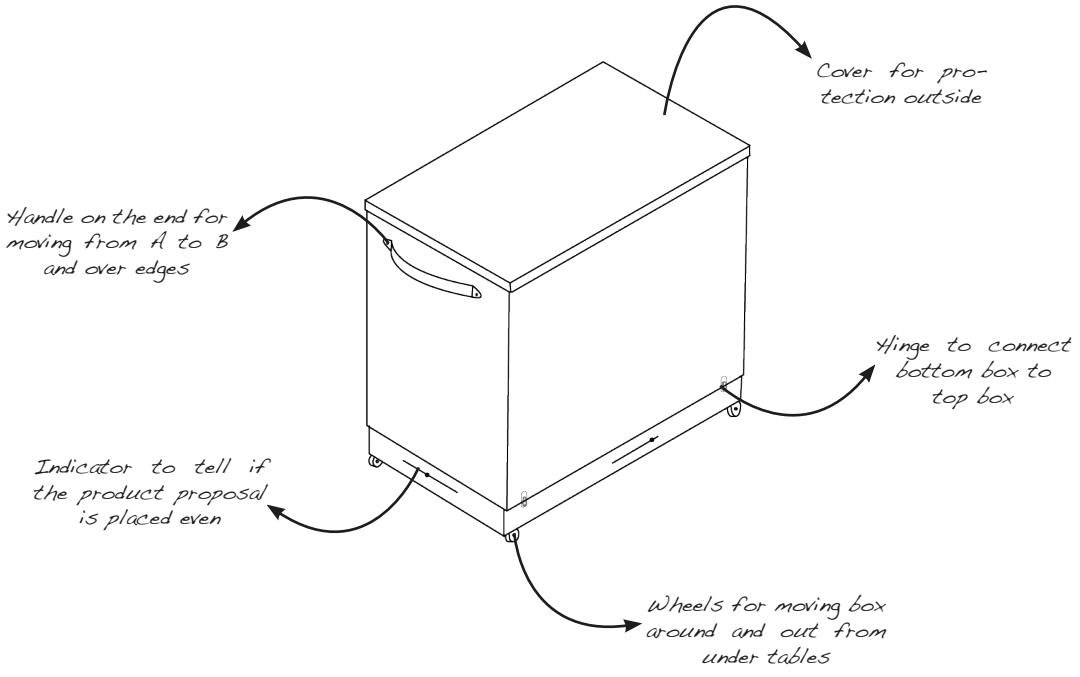
COMBINE TO ONE CONCEPT

The ideas rated useful in the two previous sketching rounds were now collected and combined into a concept with focus on the theme within each subcategory. Subcategory 4 and 6 which is component placement and feedback system were chosen to focus on later in the detailing phase. [WS56]

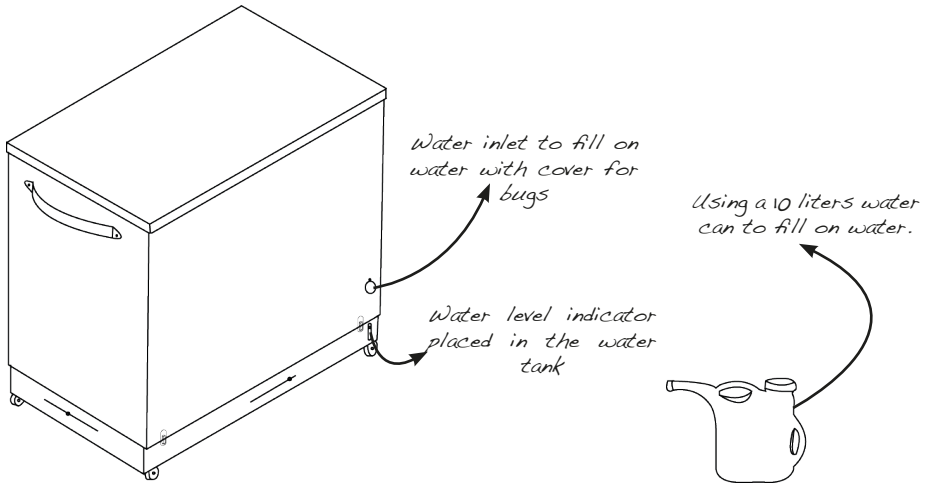
For the moving and context, elements as wheels, spirit level visualizer, handle, cover for outdoor and connection of wheel cart and the box was chosen as the most important fundamental aspects.
In prep tower the plug placement and that the plugs could be used as minimizing algae growth was in focus, also the tower holders inside the box were made smaller instead of plates for minimal material usage.
With filling the water tank a inlet was considered with a lid so no bugs can crawl into the tank. A water level indicator was also chosen for feedback to the user.
For water system and drainage the connection from the tower to the water is back in the tank was developed as a working principle. Also the watering pipes were placed inside the lid so the pipes would not be in the way when the towers are taken up or down.



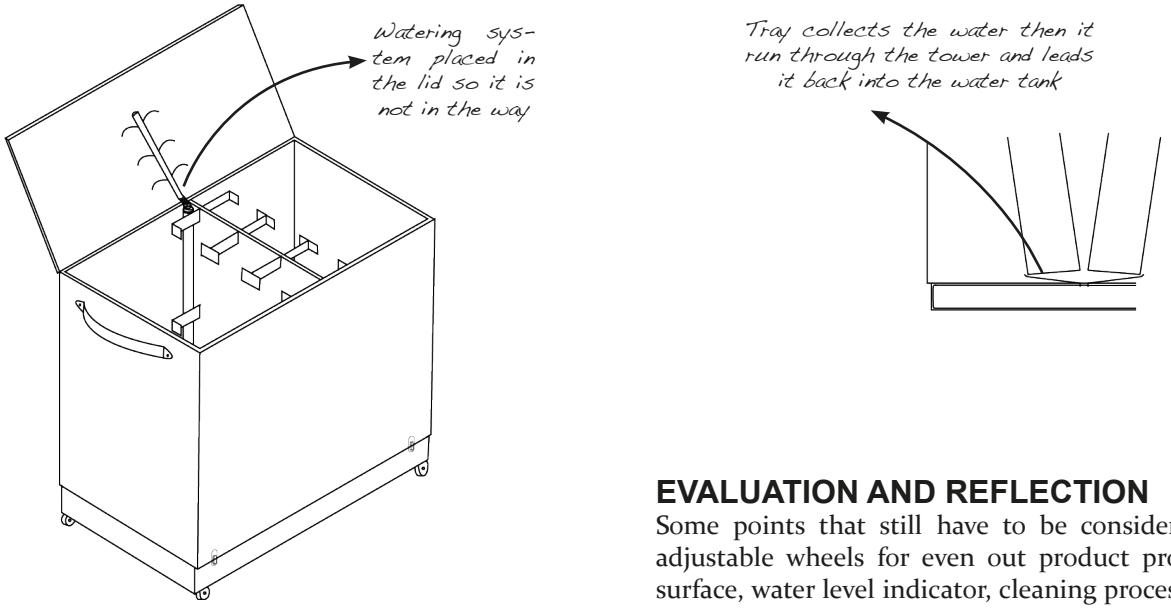
Ill. 123 - Connecting ideas from prep tower and placement



Ill 124 - Connecting ideas from fit to context and moving around



Ill. 125 - Water fill up and Cleaning



Ill. 126 - Connecting ideas from collect water and water system

EVALUATION AND REFLECTION

Some points that still have to be considered are the adjustable wheels for even out product proposal with surface, water level indicator, cleaning process, feedback and technical component placement. The sketch combination was more basic elements and only scratching the surface where there is potential for a great in depth sketching with development and ideation on interaction, meeting surfaces and functional details. The next step was to dive deeper into the details in the product proposal for both functionality, interaction surfaces and challenges which are still not settled.

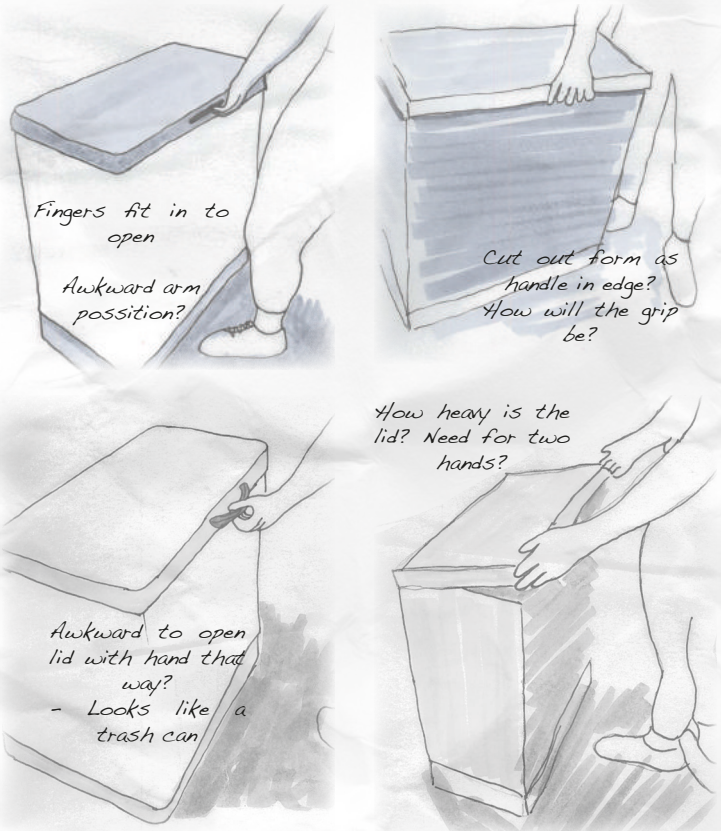
EXPLORATIVE DIVE

To fold out the details on the product proposal according to interaction and as a whole working unit, the team chose out critical interaction points of the product proposal to explore further and integrate into the whole proposal. Therefore the next 10 pages will show how this was unfolded, what considerations were made, how sketches were combined into working principles and which detail principles were chosen for the final proposal.

The critical points chosen as headlines was: Opening the lid, Moving the box out from under table, How to move the box, How to assemble the product proposal, Prepare the tower, Place the plugs in the tower and How to fill the water tank.
Under each headline some critical focus points were listed which can be found in [WS61]. The headlines was worked with simultaneously so details that would affect other details were considered according to each other. For all sketches see [WS61].

OPENING THE LID

Firstly the position and type of handle for opening/ interact with the lid were explored with different ideas on where the user would stand, how the person would reach for the product proposal and looking at where the optimal placement of a handle would be.



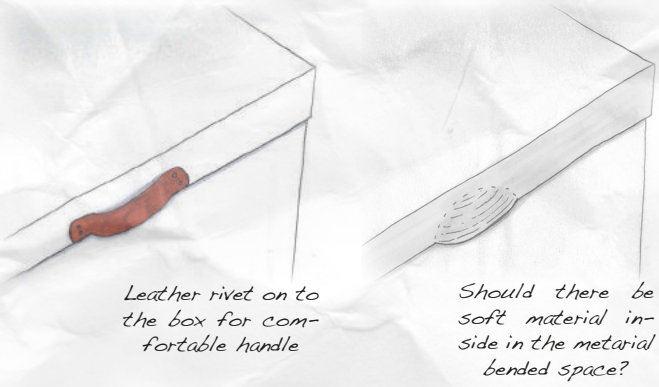
Ill. 127 - Different grip consideration for opening lid

Thoughts: What if the edge on the lid just was used for opening? But then it would be only using a little edge on the material thickness. So everything that was "flat" with the lid edge, at it was thought at first, would probably not be easy to open because of the little edge. But is was observed that the hand while opening the lid would grip in the middle of the front edge. That led to ideas of an outgoing handle mounted on to the lid. Either in top or at the side of the lid.

The different types of interacting with the lid were discussed and some kind of grip in the front was chosen as the optimal way to open the lid. But it should be explored further to find a suitable solution.
This first part of the investigation revealed questions for what needed answers, as;

- How big should the edge be and material thickness?
- If the lid has to close down on the box how much force to open.
- How much should it open? 90 degrees? 180 degrees?
- What about the hinges?

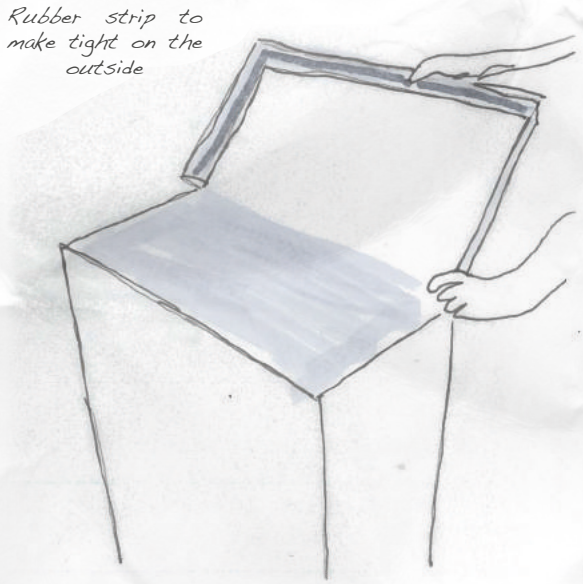
These questions were taken into new sketches to try and find a suitable solution.



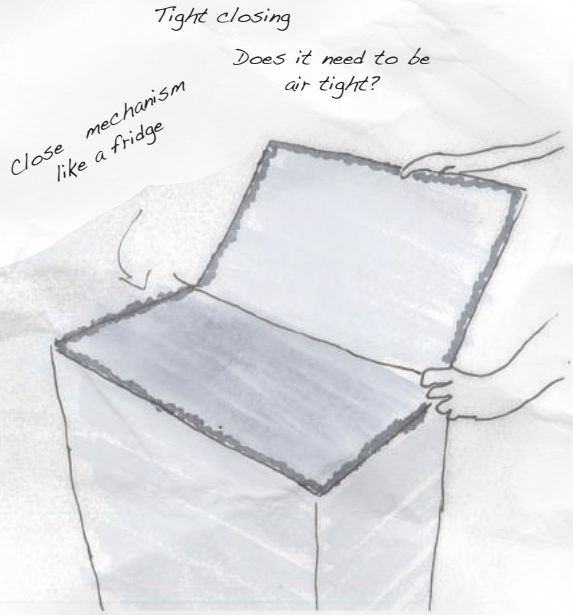
Ill. 128 - Different suggestions of a handle on the lid

As a handle it was explored; "what if it was a leather strap or integrated in the form". The team determined that a leather strap would not be suitable because it had to be used many times and leather tends to get worn and potentially break. An integrated handle into the form that bends out seemed as a possible suitable solution for opening the lid.

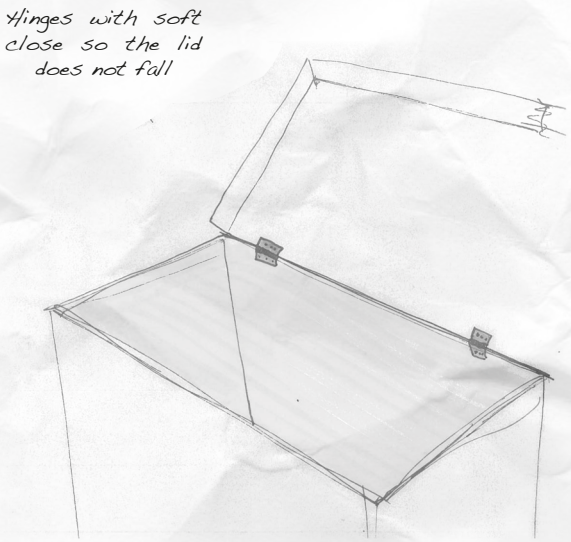
At the same time the functionality of the lid was explored to see how the lid was going to open with use of some kind of hinge, how the lid could make the box "tight" so no bugs would get in and how far the lid should open.



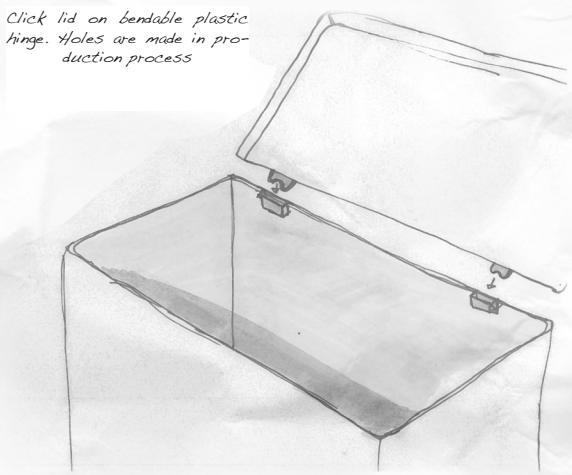
Ill. 129 - Rubber strip to seal box for bugs



Ill. 131 - Making box air tight like a fridge



Ill. 130 - Use hinges with soft close to "lock" lid in position

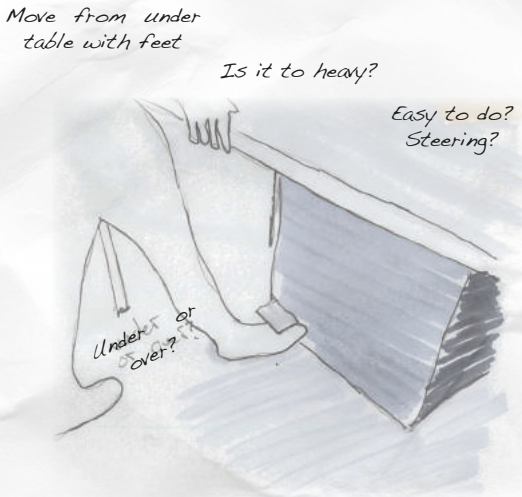


Ill. 132 - Click lid on and using plastic hinges

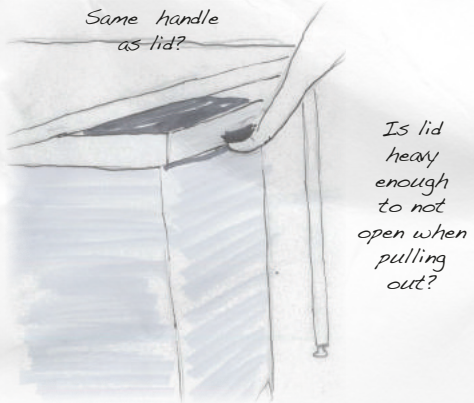
According to user friendliness and insertion of the towers the lid should be able to open at least 90 degrees up. The opening mechanism was unfolded and ideas as metal hinges, plastic hinges, hinges with soft close and so was looked at. To make the lid tight either a rubber strip was considered on the inside of the lid and the lid then closes few cm down over the box, or a closing mechanism as on a fridge where the lid is directly on top of the edge. A decision on what to use will be made later according to integration of chosen details because these factors depend on choices about the handle. But the plastic or metal hinges seemed like the most optimal for lid mounting.

MOVING THE BOX FROM UNDER TABLE

After the hinges and opening the lid were investigated, the team connected this with the scenario of moving the product proposal out under a working table in the restaurant kitchen.

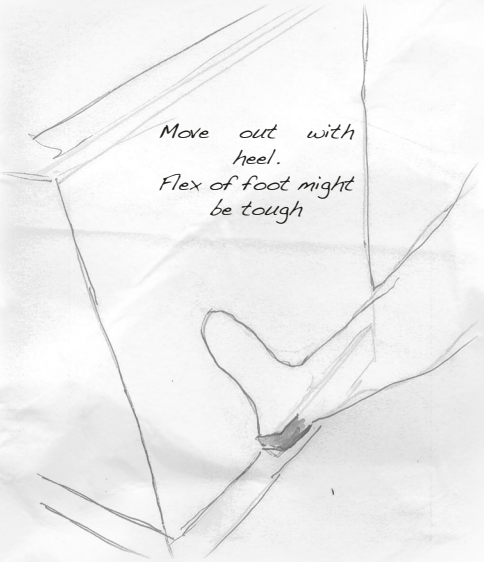


Ill. 133 - Moving the box out from under table by using foot

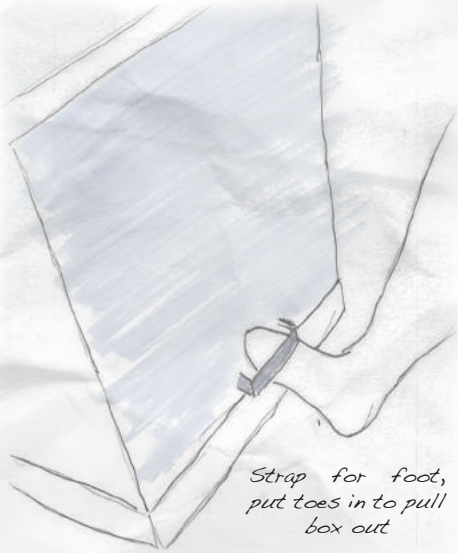


Ill. 135- Moving the box out from under table by using hand

Here the team folded out and looked at, if this interaction should be with the foot or the hand, then how would it be.



Ill. 134 - Use heel to move box out from under table



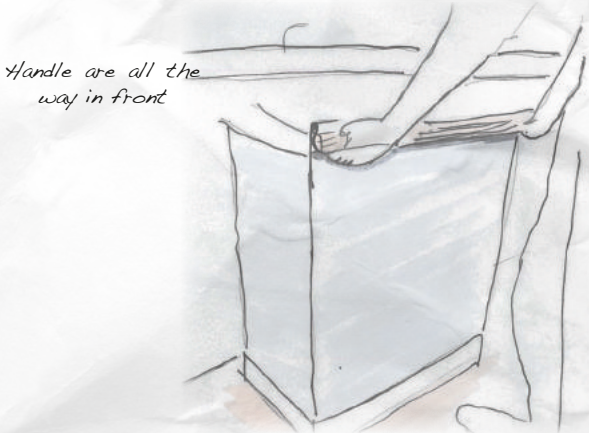
Ill. 136 - Use toe to move box out from under table

For the foot it was looked at whether the user would use heel or toes to pull it out. If the "handle" for the foot should be plastic or metal, hard or soft as a strap. But the use of foot did not seem as a very user friendly solution because the person would have to jump backwards on one leg to drag out the box, which would not be optimal both space and logistic wise. The person would have to jump backwards for 50 cm to get the box out from under a table which is far to jump backwards.

With the foot solution out of the picture, the handle integrated into the lid was looked on further.
The grip situation was tried out with the model, so how and where would the user reach for the product proposal and thereby sketch on a solution which fit the intuitive grip placement.

Ill. 137 - Experiment with handles in each side for two hands

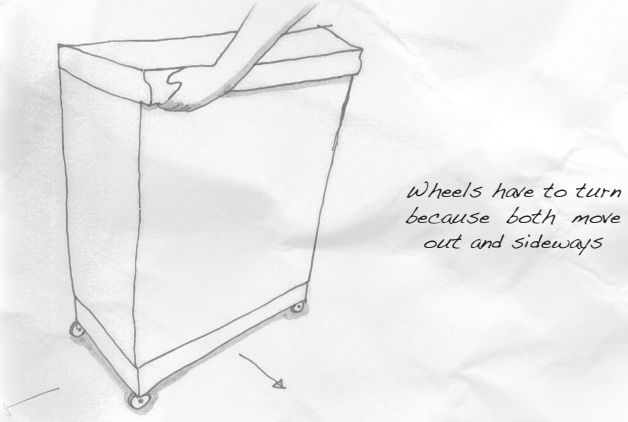
Here the thought at first was if the handle to open the lid could be used to move the box out from under the table, but because the box is wide, it would be hard to steer and when it is placed under a table the handle might be hard to locate.



Ill. 138 - A handle that goes all the way for both take out and open

Ill. 139 - Experiment with one handle in middle

Therefore the team looked at a common handle which integrated both moving out from under table and opening lid with enough space for two hands handling. Movement, easy manage and control were the key factors.

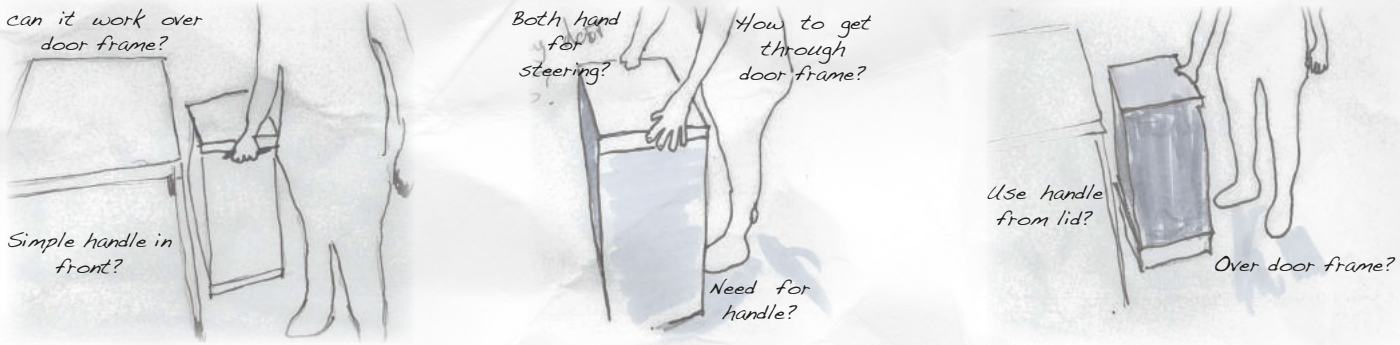


Ill. 140 - Has to have wheels for going all directions

The handle to open the lid and move the product proposal out from the table was made as a curve with a groove behind to get the fingers into. The handle is all the way at the side because of the difficulty to locate the handle when the box is under the table and the use of taking it out with two hands on the side gives more control.

HOW TO MOVE THE BOX

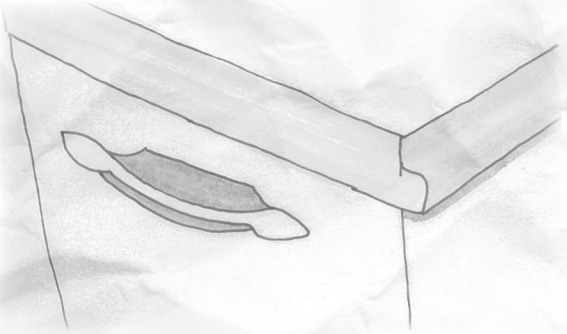
The next thing the team explored was how to moving the box from A to B and over edges.



Ill. 141 - Should the box be moved from front? side? or with two hands?

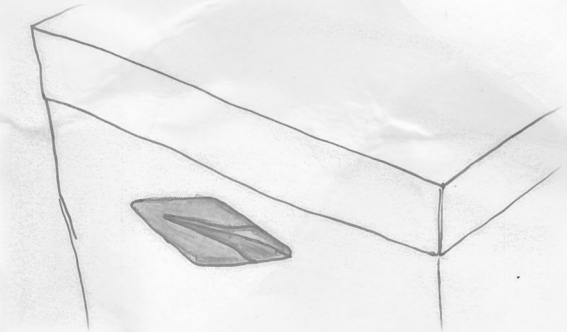
If it was most pleasant to move the box around by holding the edges, walking in front or walking on side was explored. Walking in front seemed as the most pleasant way to move the box also considering that it should be moved over edges and through doorways.

Therefore different ways on how to move the box while walking in front of it was considered. A handle and then wheels under the box seemed like the most pleasant use scenario and therefore the chosen solution.
Handles were sketched on for "walking" with the proposal, to explore form and expression.



Ill. 142 - Handle with grove to make space for fingers

Different kinds of handles were considered, both as a part of the form and separate. As a part of the form production it would not be easy to both walk with the product proposal and lift it over edges. It was discovered at the grip test that the user would put the hand down around the handle from above, so it had to be a physical handle able to grip around. The different shapes of the handles were made with inspiration in car door handles. Where the handles does not stick out to much but there is a groove in behind the handle so the hand can go in between. It was chosen to work further with the "car handle" design for the handle.

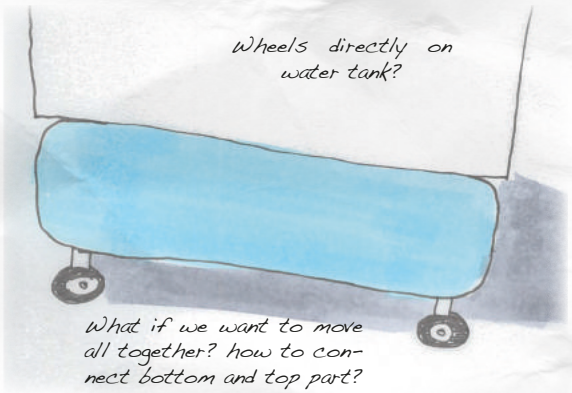


Ill. 143 - Handle with inspiration in a car door handle

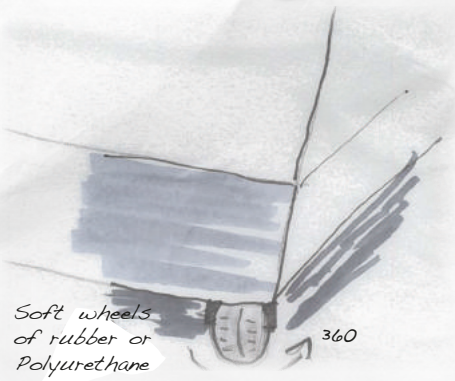
With this the team dived into the wheels situation briefly touched upon in the moving scenarios.

Different kinds of wheels were looked at and considered by thinking integration and use in the contest. The wheels should be tall enough to go over edges on 2,5 cm, but not to tall so the proposal did not get taller than 90 cm. Different ways of mounting the wheels were also considered, should it be on the water tank? Should there be a wheel cart? and how would that work with the water tank and the box. What if the box had to go both sideways and back/forth, then the wheels should be able to turn. This is the case so it was chosen to make a wheel cart with wheels in softer material and which can go 360 degrees around.

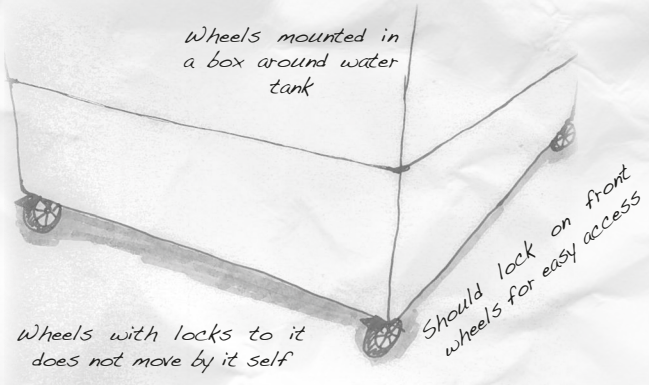
Especially the wheel mounting situation got the team to realise they need to investigate the assembly of the product proposal more.



Ill. 145 - Wheels mounted on water tank



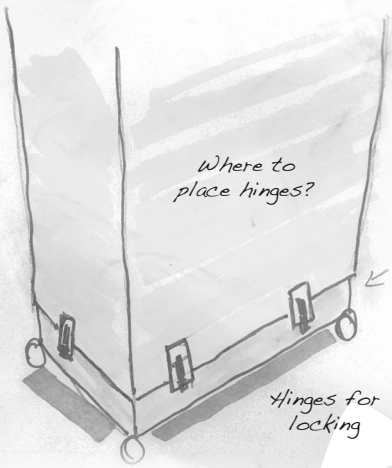
Ill. 144 - Wheels of soft material able to turn 360 degrees



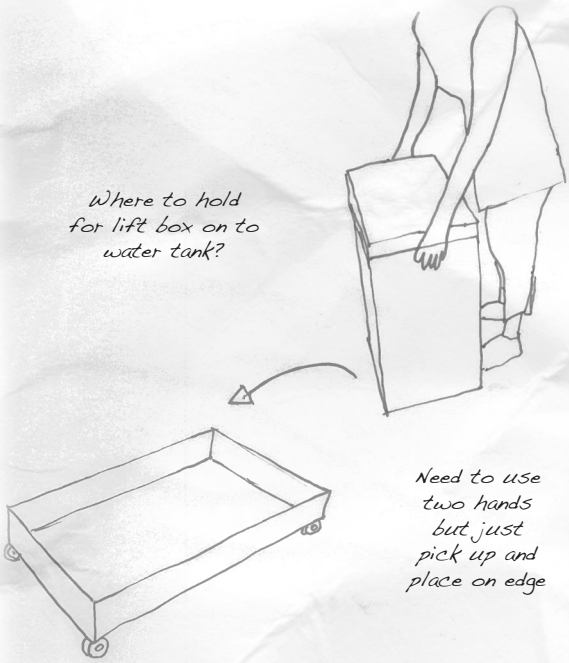
Ill. 146 - Wheels should be able to lock by foot

HOW TO ASSEMBLE THE PRODUCT PROPOSAL

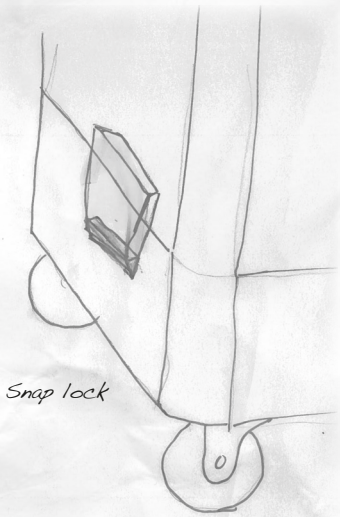
The product proposal is chosen to be divided into three larger parts where there is a wheel cart, a water tank and a grow box. These have to be connected to be able to walk with the product proposal as a whole. Here the assembly, locking of the elements, interaction,where to lock and how surfaces and edges will meet was unfolded.



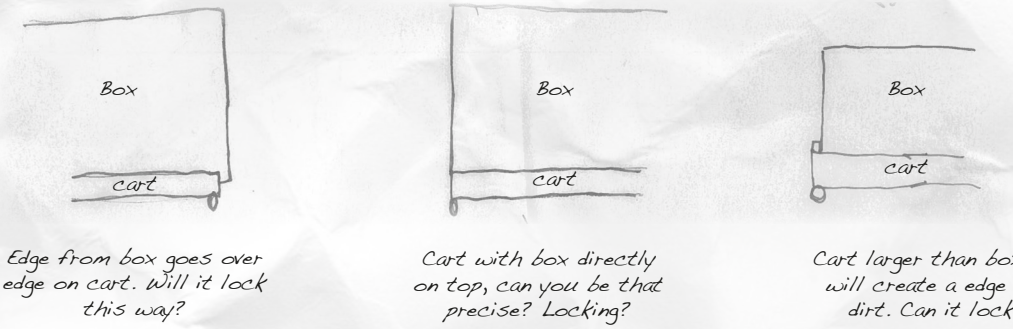
Ill. 149 - Hinges to assembly parts



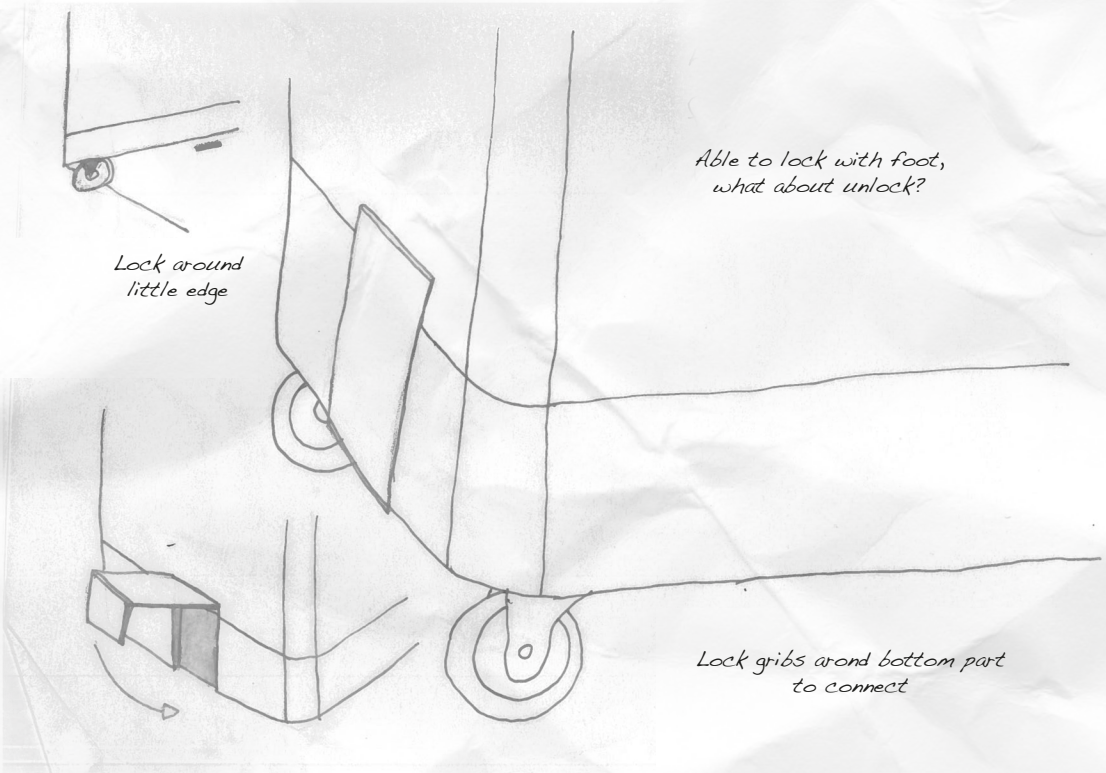
Ill. 147 - The box is lifted on to the wheel unit and water tank



Ill. 150 - Snap lock instead of hinges?



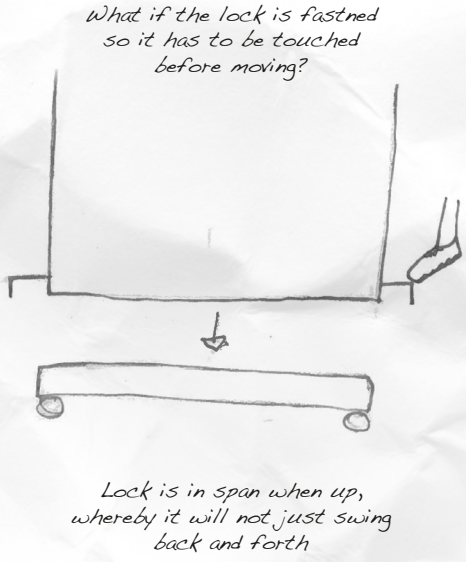
Ill. 148- How should the edges meet? On top or over lap?



Ill. 151 - Lock that presses the two parts together.

The water tank placed inside the wheel unit would make the connection between the two boxes more smooth. It was considered whether the connection should overlap or just be on top of each other. On top of each other was chosen for better locking opportunities. Also there would be no edge for dirt to lay on. Different locking mechanisms were explored and discussed according to easy handling, should it be by hand or foot? Should it be small or large? And where could it be placed to lock the two boxes together so it is possible to move the box. It was decided that it was most optimal if it could be both locked and unlocked by foot, and the interaction surface should be large enough.

But one question raised with the chosen lock mechanism. Would the locks just hang and dangle when the box is placed on top of the wheel unit?
This would at this point be solved by utilize the plastic elasticity so the lock would sit in span and therefore not fall down and be in the way.

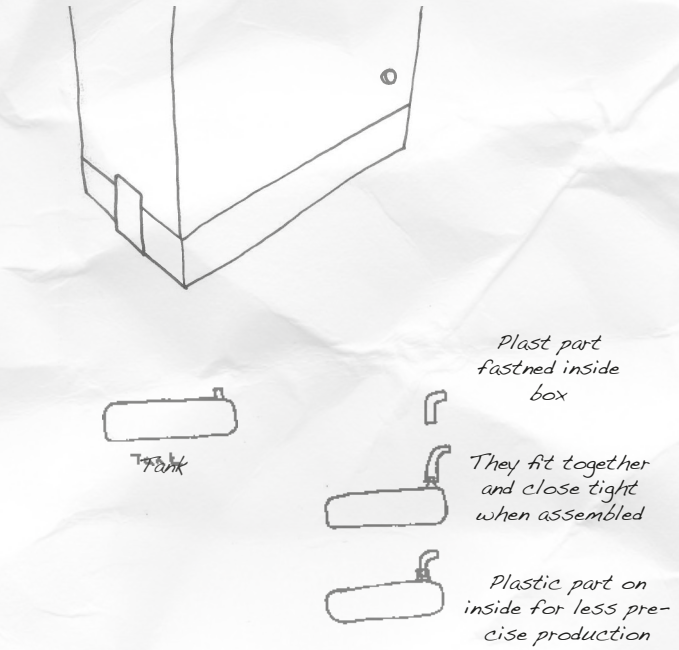


Ill. 152 - Lock in span so it is not in the way during assembly

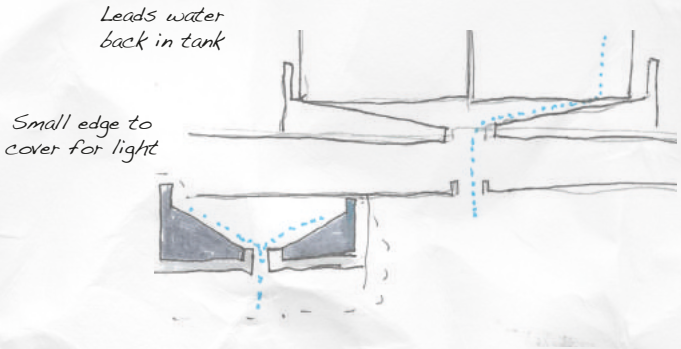
HOW TO FILL THE WATER TANK

This resulted in the team discussing and exploring the water tank interaction with the box and how the water flow was and how to put water into the water tank when it is placed inside the wheel unit. How to place the pump that ensures water flow through the product proposal down into the water tank was explored. How to make the inlet secure from insects was also included.

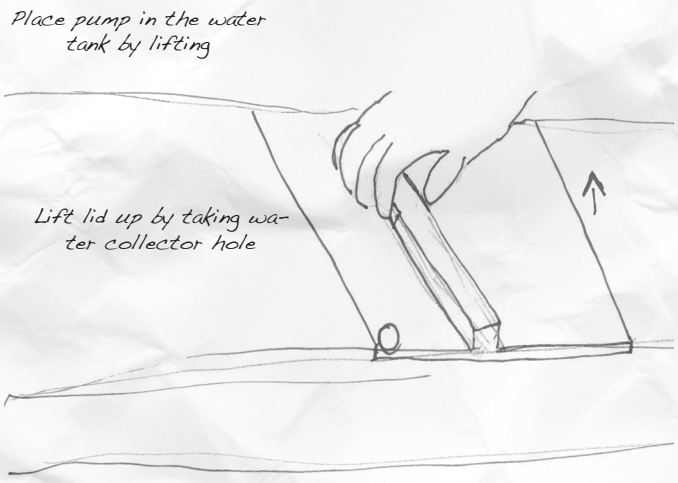
Filling water in the tank was unfolded by considering different placements for the inlet. Here directly into the tank, inside the box and by a tube placed higher was considered. Directly in the side of the tank did not seem to work because the tank could not be fully filled up then. Inside the tray the user would need to lift the water can high and the towers would be in the way. A tube placed low on the grow box which could lead the water down in the tank seemed as the most optimal solution. For covering the inlet either a little door or a "lid" was considered where the turning lid was chosen because it was an easier interaction. To place the water pump inside the water tank different solutions were considered. It was important that it was easy to get to the pump if it had to be repaired at any time. Therefore a lid on the top was chosen where it will be in span and not movable when the whole product proposal is assembled.



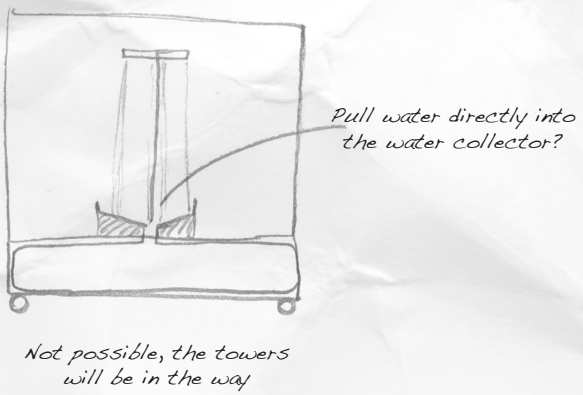
Ill. 153 - Fill tank from over the tank but still placed low



Ill. 155 - Collect water back in tank by angled tray



Ill. 154 - Lid on water tank for placing and reparing water pump



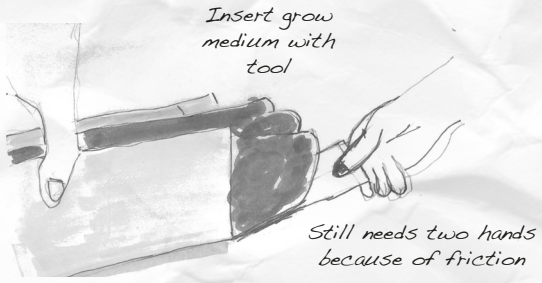
Ill. 156 - Fill water in tank between the towers

PREPARING THE TOWER

The harvest and seeding process were explored next in relation to the product proposal. This has already been developed and sketched on before, but with the new ideations the team wanted to give it another round with focus on interaction surfaces.

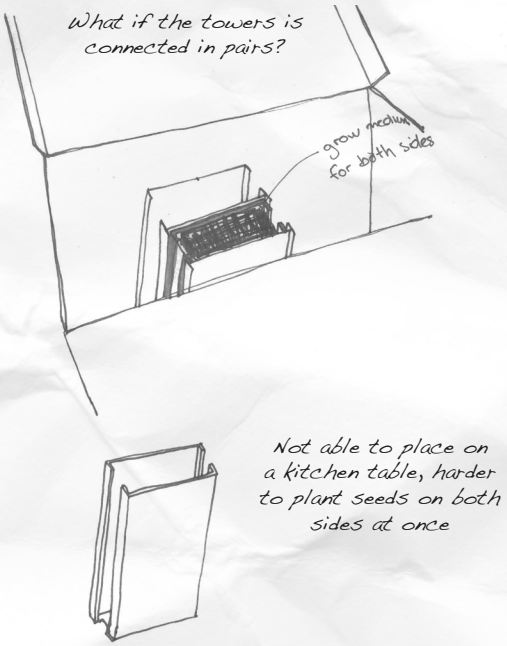
Here the size of the growing towers its grow directions, how to harvest, seed and insertion of the grow medium was explored again. Another thing that was explored simultaneously was where the tower would be placed when harvesting and seeding, could the edge of the box be used?

Ill. 157 - How to place the grow medium?

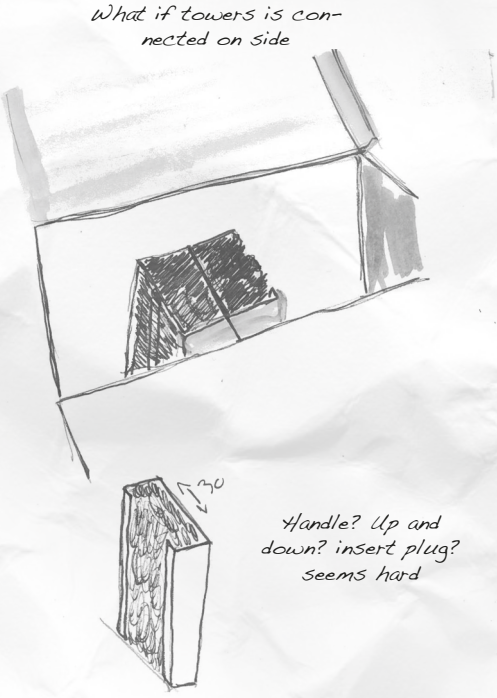


Ill. 158 - Placing grow medium with a tool?

The team tried to explore tower proportions in different directions but chose not to develop further on it because of the limitations it will give in scalability, limiting the amount of different crops per box, the interaction when taken out of box would be more difficult and take more time and also it would affect the wish for the "harvesting one tower a day" principle.

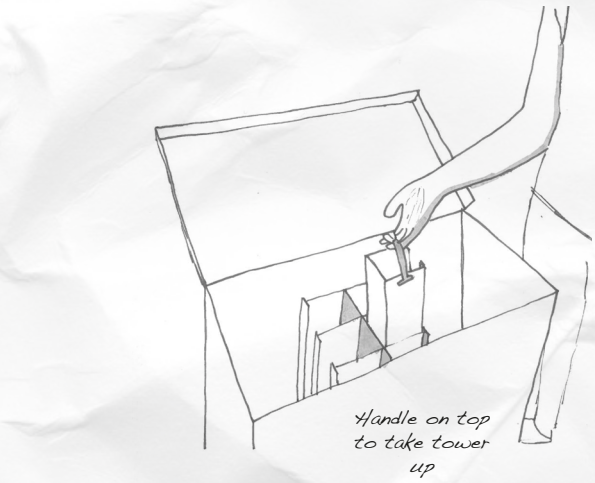


Ill. 159 - What if the tower was in pairs?

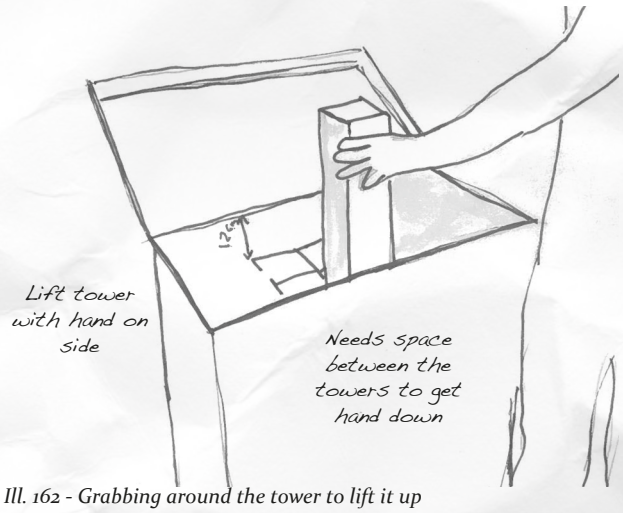


Ill. 160- What if the towers was connected on the sides?

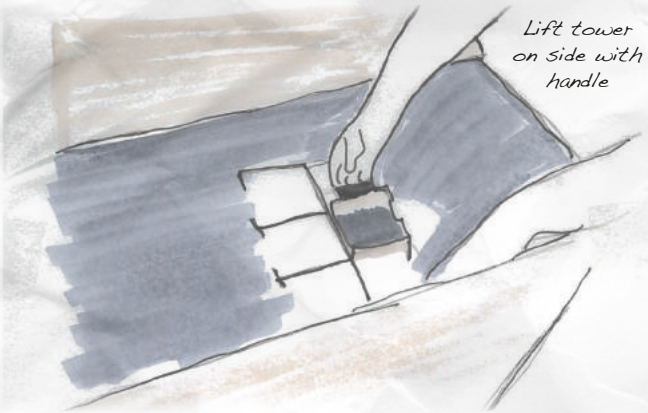
The towers were thereafter explored to figure out how to place it in the box and what type of mechanism should be used to make it stay in place. Grip on tower and handles was explored as well at the same time.



Ill. 161 - Handle on top for lifting up tower



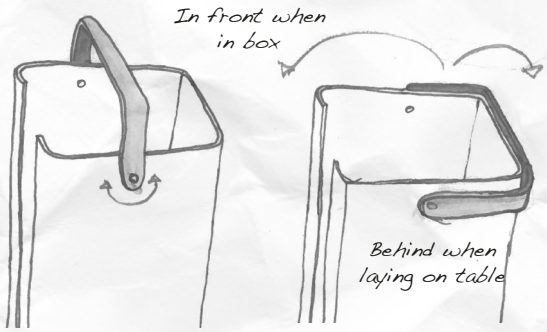
Ill. 162 - Grabbing around the tower to lift it up



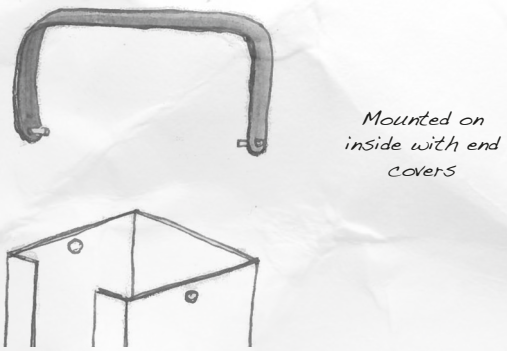
Ill. 163 - Handle on side for lifting up tower

How to take the towers up of the product proposal was looked at with the demand in mind that it should be placed at a table when harvest and seeding. Hand placement for optimal control over taking up and putting down the tower was testet and a handle/strap on top of the tower seemed like the solution which would give the best grip and control over the tower. The handle should also be thought as a solution where the tower can be placed in an angle in one end so water will not run out when it is placed on a plain surface. To secure the tower in the box, a hanging solution was considered, but sliding the tower down into some holding element still seemed like a better solution for stability.
After choosing that it should be a handle, how the tower handle should be in expression and assembly was investigated. The interaction with use of a handle was tested at Fladbro Kro afterwards [WS60].

Ill. 164 - Different handle shapes



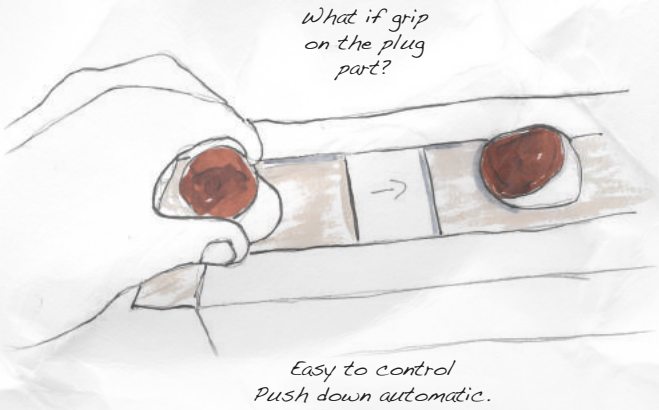
Ill. 165 - Handle should be turnable



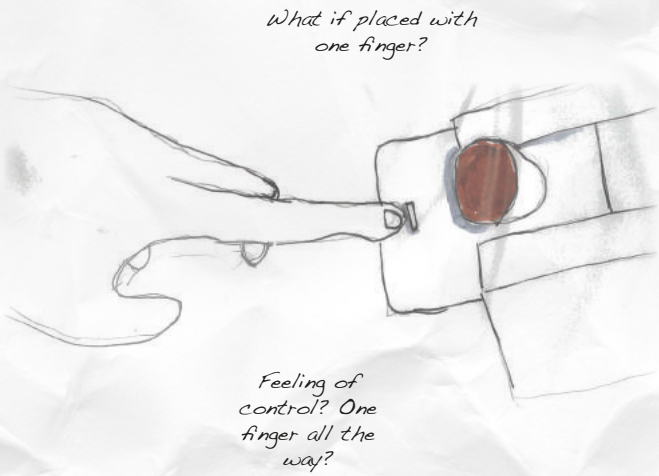
Ill. 166 - Handle mounting on tower

The simple handle which follows the edge of the tower was chosen and the mounting of the handle onto the tower was determined.

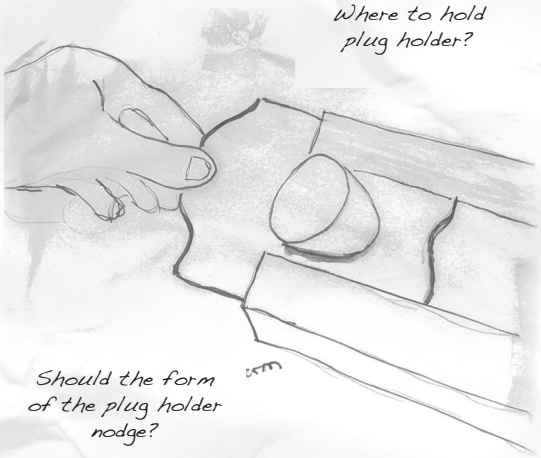
The next step was to look into the insertion of the plug holder in the towers. How should the interaction be?



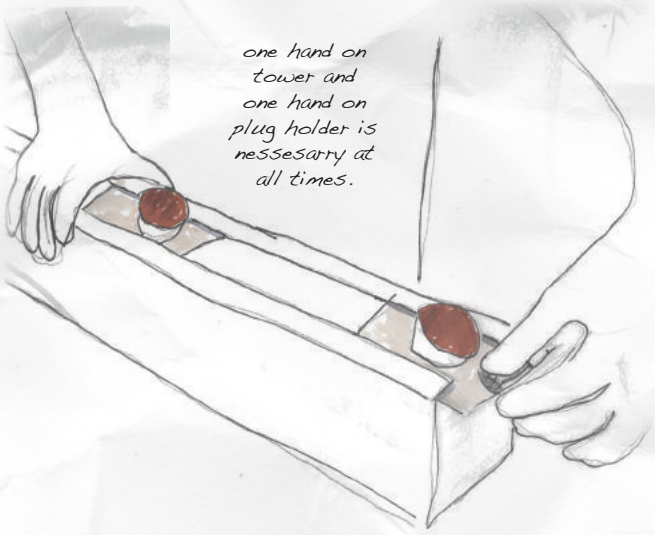
Ill. 167 - Using hand to place plug holder



Ill. 168 - Using finger to place plug holder



Ill. 169 - Using fingers to place plug holder, shape helps guiding



Ill. 170 - Using fingers to place plug holder

It was considered where to grip on the plug holder and if the user should use one or two hands, or even just one finger to place the plug holder into the tower. A indication on where to hold the plug holder when it is inserted was chosen for further development. The user should insert by interacting with the plate and not the place where the plug is going to be inserted.

EVALUATION

After the process on looking into the different critical points of the product proposal the team selected the ideas that fit best with the demands and the proposal as a whole. These are going to be further developed and integrated into the final proposal in the detailing phase.

REFLECTION

For another time the team would have started sooner to explore the interaction, surface, movement and construction earlier to iterate more on the product proposal in details compared to the whole proposal.

This explorative ideation has not been a linear process, and resulted in a difficulty to create a true documentation of the task. To explain it, it was necessary to choose an order to show the sketches and it is seeked to describe how the sketches and questions lead to new explorations. This causes that it seems as it is divided into criterias which were not considered according to each other which is not the case. The team jumped back and forth as the sketching evolved and new challenges surfaced. Throughout the sketching the points are considered in collaboration with each other and not only focusing on solving one thing before moving on.

FROM CONCEPT TO ACETARIUM

After the explorative dive into the details for the product proposal working principles were chosen out, combined into one proposal and visualized in CAD. The choices were based on functionality, established design demands and how the different parts will interact with each other and the user. See the CAD visualization on (ill. 171).

INTERACTING WITH THE BOX

On the front of the box should be placed a handle for opening the box lid, but also move the box out from under a table where it might be stored. Therefore the handle should be able to grab with both one or two hands. On the edge of the lid, there should be a barrier so bugs can not crawl inside the box. The lid should be mounted onto the box with hinges that preferably can deliver a resistance so the lid does not accidentally open. For moving the box around in the context a handle on the end of the box and wheels under is optimal. The wheels should be in a softer material like rubber or polyurethane so it is easier to get over edges and the wheels should be able to turn around for great mobility.

WHEELS AND ASSEMBLY

For the wheels not to be mounted directly on the water tank, a wheeled cart with high edges so the water tank can fit inside could be used. The wheel cart would be locked to the box with some kind of snap lock that can be handled by using the foot so the user does not have to bend over. The box could preferably fit directly on top of the wheel cart to not make an edge but a shadow in between the parts, this would prevent an edge where filth could lay.

WATER SYSTEM

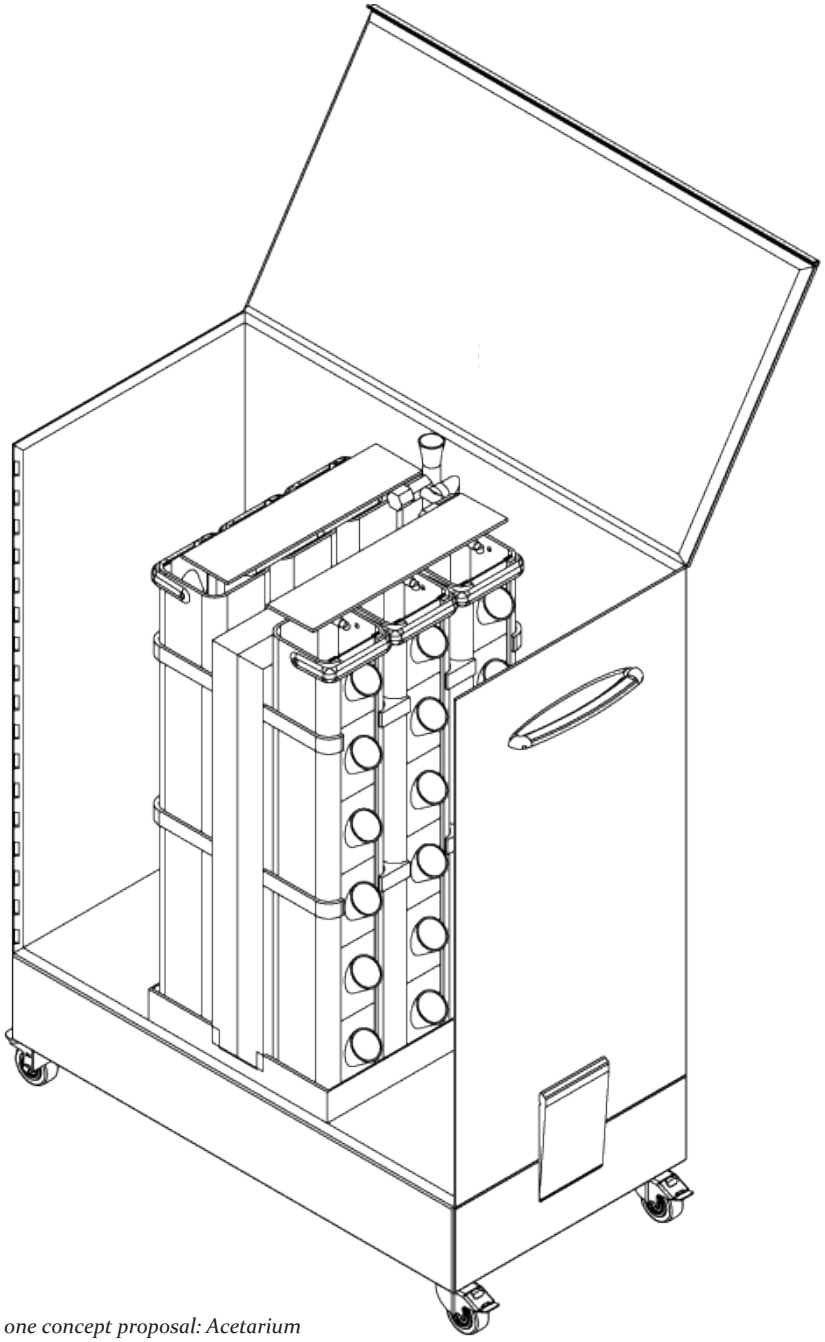
Filling water into the tank will need a water inlet placed in an easily accessible spot and will be filled by using a water can. Inside the box, the water system is supposed to go in a loop to use as little water as possible. Therefore a collecting tray is to be placed under the towers to lead the excess water back in the water tank. The tank and the tray will have an open connection.

TOWER PREPARING AND INTERACTION

When preparing the towers the grow medium will be placed first by using two hands, one to hold the tower and one to slide the grow medium in. Thereafter the plugs with seeds will be placed in the plug holders which will be slid into the tower, and thereby the end of the plug holder will split the grow medium and ensure correct placement in between the grow medium. On the tower there should be a turnable handle on the top so the tower can be taken up and down, the handle will also be used to place the tower in an angle so no water will flow out on the table when the tower is being prepared or used in the kitchen. When the tower is placed inside the tower holder in the box the handle can be turned forward to not interfere with the water system. In the bottom of the tower, there is a cut out so the water will run out, but it still needs a bottom to cover for water running out when placed on a table.

EVALUATION

The proposal is at this point still a concept consisting of working principles, but after the explorative dive, the concept is forming into a product proposal. In the deliver phase the technical aspects, material, assembly, and production choices will create a more specific product proposal.



Ill. 171 - Ideas connected into one concept proposal: Acetarium

Ill. 172 - Deliver introduction

DELIVER

The remaining detailing is presented in the deliver phase. Here the technical limitations that have been needed to get the product proposal to work are explained. A feedback system is explained, the whole product proposal, material and production are specified and a business strategy is discussed for how to sell the product proposal.

Chapters

- Knowing the technical limitations
- Feedback system
- Sustainability considerations
- Acetarium specifications
- Material and production
- Business strategy

KNOWING THE TECHNICAL LIMITATIONS

To get a more tangible idea of the technical limitations that have to be in the product proposal the light, watering method, climate control, nutrients, grow medium, water pump and technology box were specified. Throughout the project, the team early on had an understanding of what technical components were needed, but until this point, they were not specified.

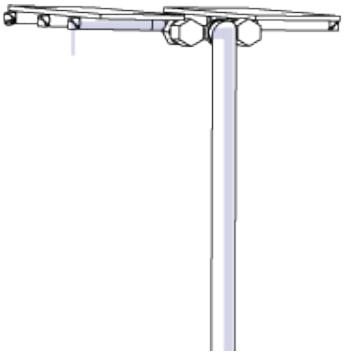
LED GROW LIGHT

The leafy greens need light to flourish. 18 hours of light and 6 hours of darkness. [Thespruce.com] The light used are LED strips placed in front of each tower to steer the plants straight and provide the necessary light to each tower. There will be six strips in each box, each strip is 400 mm long and 15mm wide. To read more into the technical application of the light see [WS41].

Ill. 173 - LED strip for optimal growth

WATERING SYSTEM

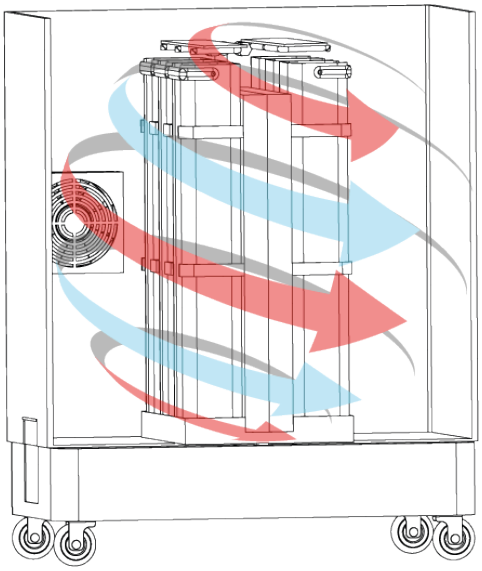
The product proposal uses drip ponics to water the grow medium which leads the water to the plants[WS42]. Water is pumped from the water tank into a tube and up into the drip emitters. The drip emitters can be turned 90 degrees before interaction with the towers so they are not in the way. This 90-degree turn closes the water flow with the use of a ball valve to ensure no dripping when interacting with towers [WS62].



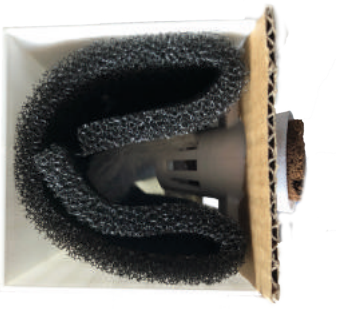
Ill. 174 - Watering system with drip emitters

AIRFLOW

The climate system is to flow air in and out of the product proposal [WS43]. Without exchanging in air the leafy greens cannot survive. This is done with a fan that provides air flow throughout the growing space. The fan is placed on the back side of the box in one side.



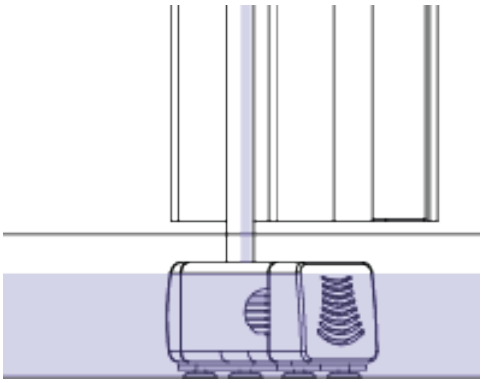
Ill. 175 - Airflow inside box



Ill. 176 - Plug, plugholder, grow medium and soaking cloth

NUTRIENT AND GROW MEDIUM

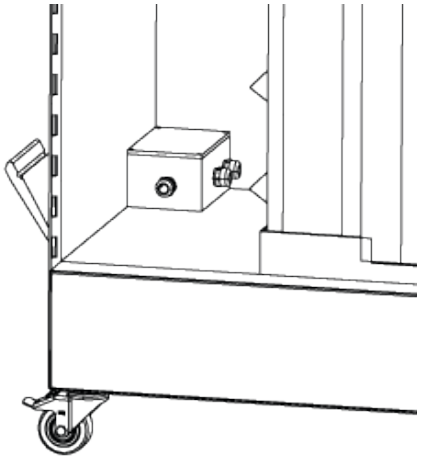
Nutrients are essential for growing leafy greens. The composition can be bought premixed as a standard solution [WS44]. The grow mediums are 2 different parts. For the seeds to germinate it is placed in coco coir plugs and for the leafy greens to grow the plug holders help the roots to grow into a plastic based grow medium. Between the plastic grow medium is a soaking cloth to keep the plugs wet.



Ill. 177 - Water pump inside water tank

WATER PUMP

The water pump is placed inside the water tank on the bottom with suction cups and its power cord is placed through a hole in the water tank and into the growing box from the outside for power connection. The pump needs to be taken out of the water tank if the restaurant wishes to clean it.



Ill. 178 - Junction box for electronics

CPU

The CPU controlling the system is placed inside a junction box below the light in the grow box. Here all the wires are connected into the junction box. On top of the junction box is a power button to turn the product on after connecting it to power.

FEEDBACK SYSTEM

To improve the trust between the user and the product proposal, a feedback system was thought into the proposal. From an interview with Fladbro Kro[60] the team got to know that the potential user would not like a lot of information from the box and that the information should be given by an app and not a screen on the box. If there was no reason, they would not check the box every day.

Therefore a communication via an app solution was suggested. Here the user would only get the information needed to know if something is wrong. The most critical fault would be if the water flow stopped because since the plants do not have any soil the roots would dry out faster than usual. The App should also be able to tell the user if the power is out.

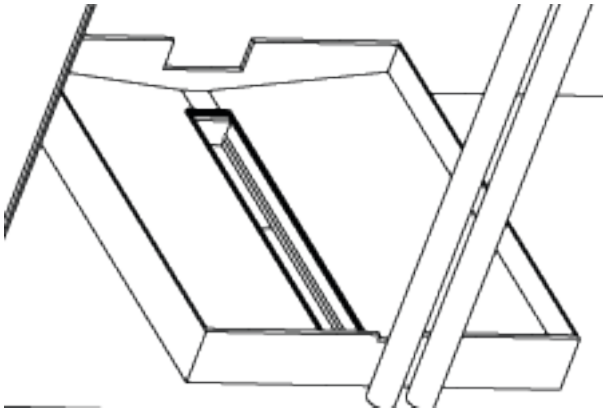
Therefore a water leakage detection sensor line[coocking-hacks.com] was chosen to install on the edge of the water outlet under the towers. This sensor will detect when there is water present. It will be connected to the technology box and send a signal to the app when the sensor has not detected any water in 12 hours.

When the user is filling the water tank, there should be some kind of feedback. Because the filling is happening in the tube placed in the box, it is optimal of the feedback on when the tank is full also is shown in the box. Therefore 2 water level sensors are placed inside the tank and connected to the junction box. At the junction box, there are two diodes which will indicate when the water level is to low and when the tank is full [WS64].

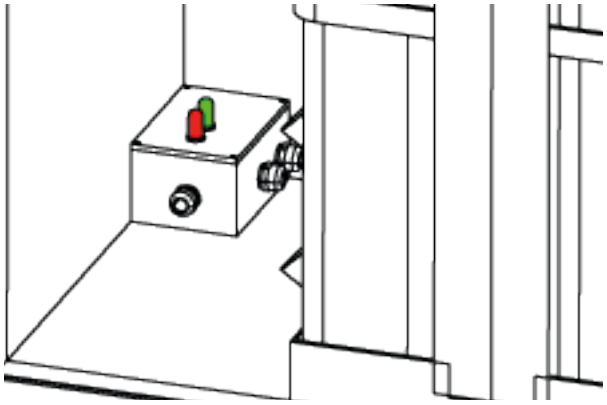
To make it possible for the user to plan when to plant and harvest, a planning tool is also considered for the app, so the user can know when the plants are ready if the user has bought more than one box. In the interview with Fladbro Kro, this planning solution was discussed with the user. She wanted to be able to decide herself when the leaves were ready for harvest because of the leaf size varies from dish to dish, it depends on what they want for the visuals of the dish. Further, she said she would harvest and seed continuously to always have something to harvest. [WS60] Therefore this was not further considered.

EVALUATION

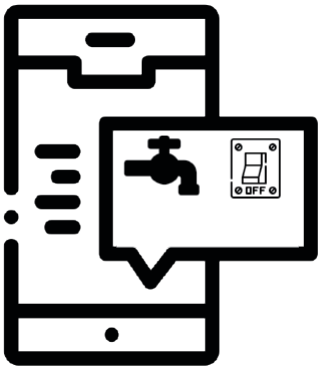
The app should only notify the user when there is a failure in the watering system. This is the most crucial part that can fail and the one that will have the worst and fastest impact on the plants.



Ill. 179 - Water leakage detection sensor placed in tray outlet



Ill. 180- Diodes are used to inform when the tank is empty or full



Ill. 181 - An app is telling the user if the water system is blocked or turned off

SUSTAINABILITY CONSIDERATIONS

POWER USE ESTIMATION

To make an estimation of how much power the product proposal will use per year, components power usage were found and calculated for power usage per box. In [WS52] the components and power usage are listed.
The components taken into account are; LED strips, water pump and air control.
These components use approximately 219 kWh per year.
If it runs every day, for 2,29 DKK in electricity price, the price per year will be approximately 500 DKK.

SUSTAINABILITY CALCULATION

The power use estimation is used to make a sustainability calculation on how much CO_2 kilograms the power usage of the product proposal will deduce compared to the transport of leafy greens from southern Europe. [WS50]

According to [Naturerhverv.dk] a restaurant that uses 4 kg of imported leafy greens a week has a CO_2 footprint on 134,4 CO_2/kg per year.

In the power usage estimation, it was calculated that the product proposal will use 219 kWh per year, which is 43,8 CO_2/kg.

The product proposal is therefore calculated to deduce 3 times less than it takes to get imported leafy greens.

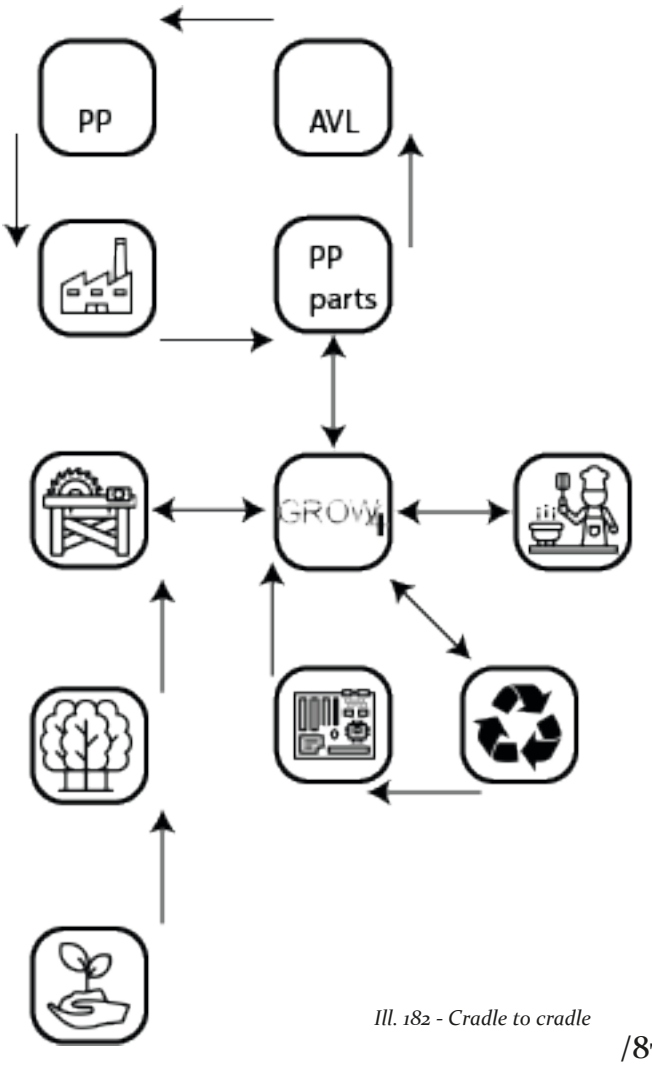
EVALUATION AND REFLECTION

The co2/kg estimation looks acceptable in the aspect that the team wants to deduce less co2 than normal. But power usage vs transport and storing co2 usage does not cover the whole picture. There is still the production site of the transport truck and the product proposal, there are aspects as material production, water and storage which is not accounted for.
The estimation still lacks a lot of aspects. But the calculation takes hold in that the team will eventually challenge the delivery of leafy greens, and therefore the delivery and power is weighted against each other where the teams product proposal is more CO_2 friendly than getting greens delivered. The team acknowledges that there is much more to be made for this calculation, but the growth and transportation from southern Europe vs the product proposal power usage in CO_2 seemed like the most important comparison because that is what this product proposal is concerned with.

CRADLE TO CRADLE

The team wants to have some requirements for sustainable production for the suppliers.
Polypropylene (from now on referred to as PP) is from Aage Vestergaard Larsen[avl.dk](from now referred to as AVL) and has been 90% made from recycled PP and 10% virgin PP. The team will require their production partners to use PP granulate bought from AVL to produce the plastic components. When the team gets a return of the product the plastic parts will be sent to AVL to be made into new granulate to create a near closed loop.

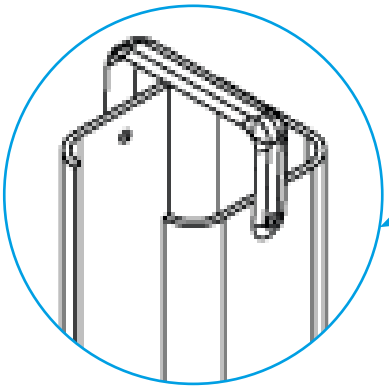
The wood elements in the product proposal are made of Danish pinewood plywood. For every product made the team will plant a tree to give back what is taken from nature. The plywood is cut, assembled and laminated at a carpenter who when the restaurant returns the product can take back the laminated pine plywood and cut them into other furniture such as shelves or kitchen doors. The technical components are hard to recycle directly. Therefore collaboration with the supplier and recycling centers is established to recycle the materials in the components if the components cannot get a second life.



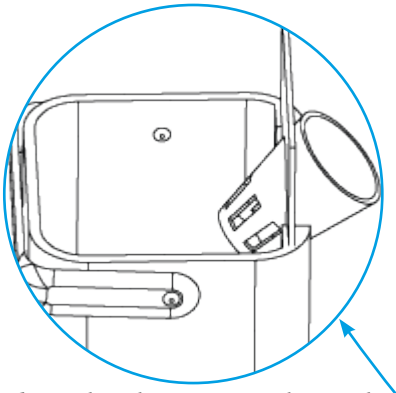
Ill. 182 - Cradle to cradle

ACETATIUM SPECIFICATIONS

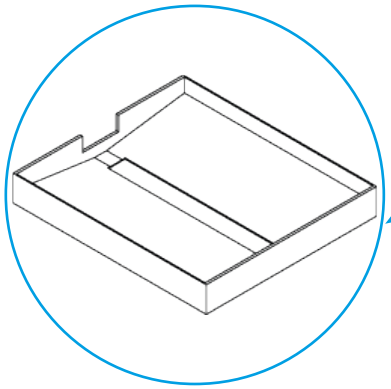
The product proposal is divided into a lot of parts that together act as a unit for growing leafy greens in the restaurants.
Here all non-technical parts will be accounted for.
The outer dimensions are 700mm x 370mm x 860mm.



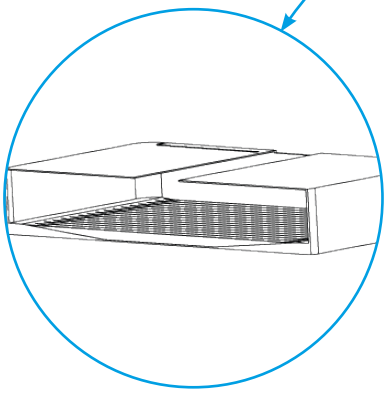
Tower: The towers are 600mm tall and 100mm wide. They can grow 6 plants each. At the top, there is a handle that can rotate 180 degrees to ensure both a grip for inserting the tower and angling when placing the tower horizontal on the table.



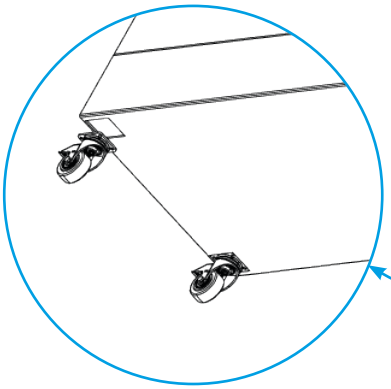
Plug: The plug is inserted into the tower. This ensures an angle of 45 degrees which help to keep the seed in place during the handling process.



Tray: The tray is connected to the male part that steers water down into the water tank. The trays purpose is to keep light away from the water to avoid algae and to steer water from the towers and into the water tank. The water flow through the tower and back into the tank was tested and documented in [WS59].

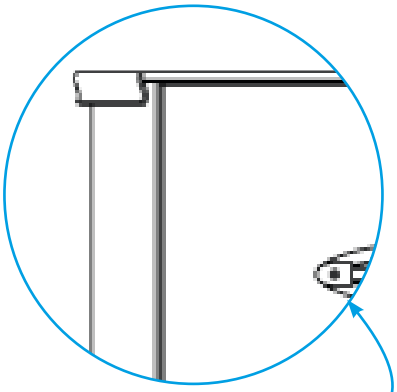


Water tank: For the water to be guided down into the tank, the bottom of the tank is angled 5 degrees towards the middle. In the bottom are there furrows to break the water when moved. See other considerations in [WS63].

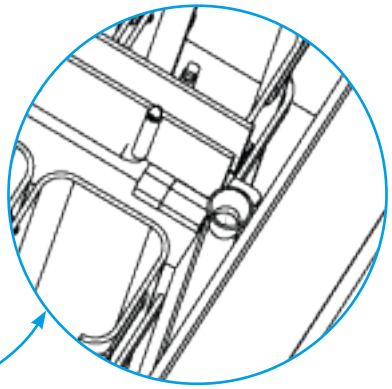


Wheels and cart: The wheels are placed in the bottom where a groove is milled for them. They are mounted on to the wheel cart afterward.

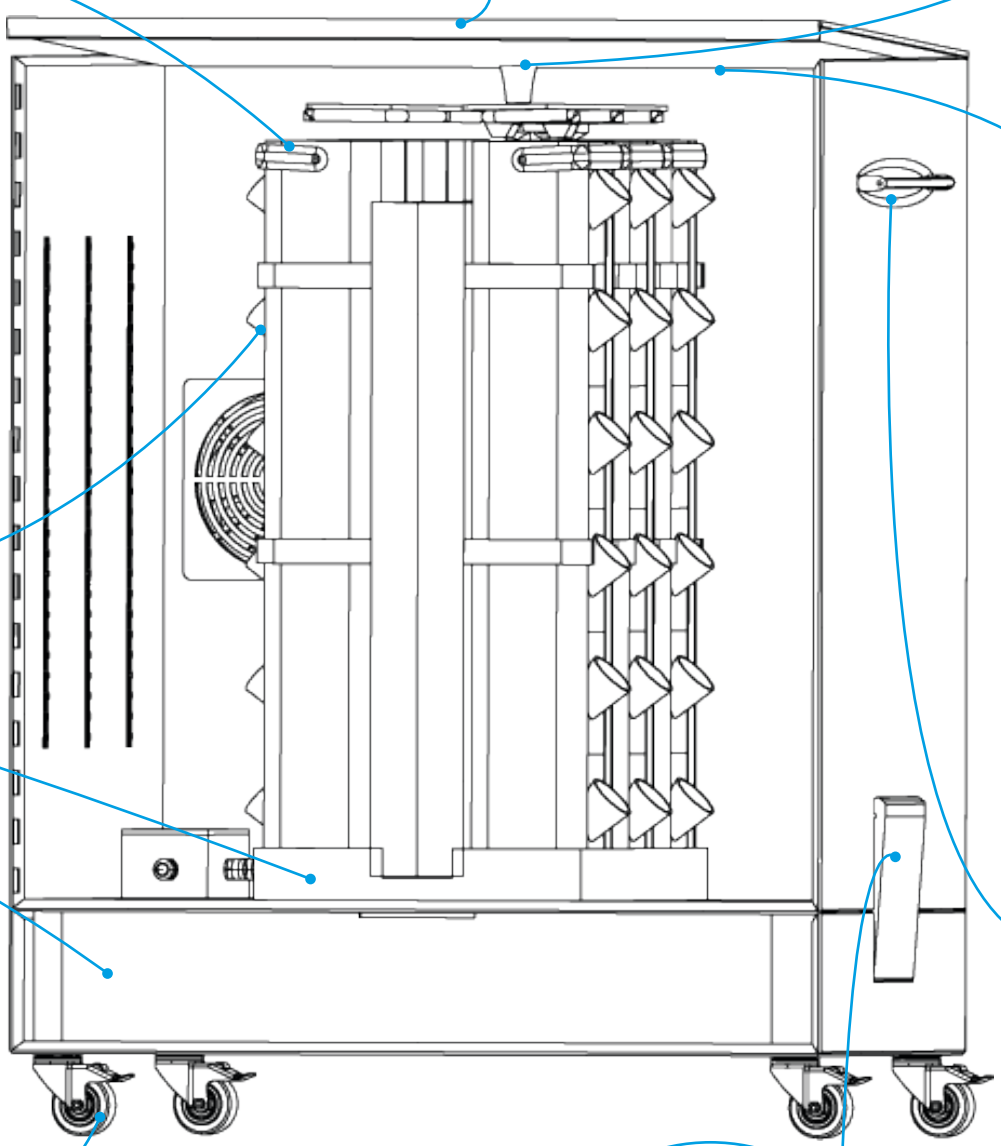
Ill. 183 - Walking through the proposal

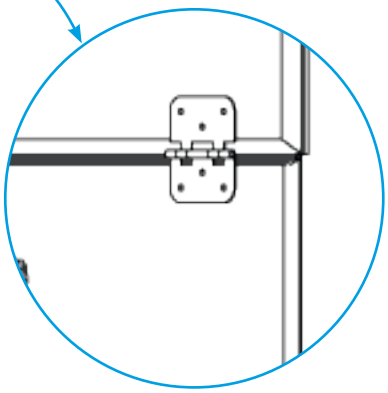


Front handle: The handle on the front of the lid is curved out from the box all the way, so the user is able to grab underneath to open lid and move box out from under tables.

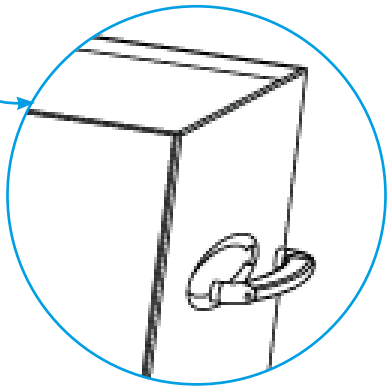


Water fill: To refill the water an inlet is placed beside the tube for the water system. Here the user can refill the water with a hose, water jug or water can.

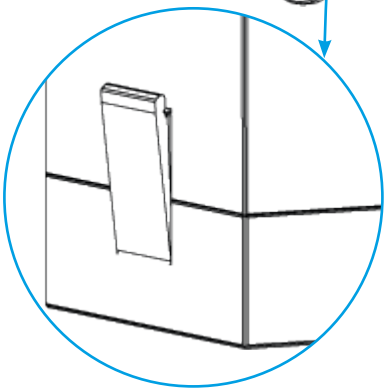




Hinges on lid: For the hinges in the lid, a HESD 120 hinge is used. It has an opening width of 180 degrees and can hold up to 40 kg.



Handle on end: A handle is placed on the end to secure easy steering when the product proposal is moved around and over edges. The handle is fastened with screws in the end.



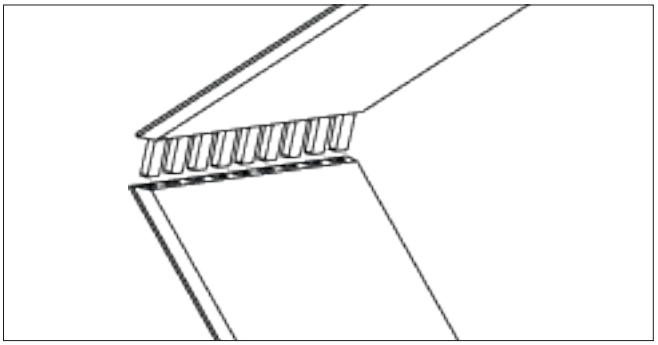
Lock: To lock the wheel cart and the grow box a snap lock is used. The snap lock is an annular snap joint made in aluminum.

MATERIALS AND PRODUCTION

Here the production methods and materials chosen are explained. To see the whole process of choosing materials and production methods see worksheet 57 and 65.

BOX AND WHEEL CART

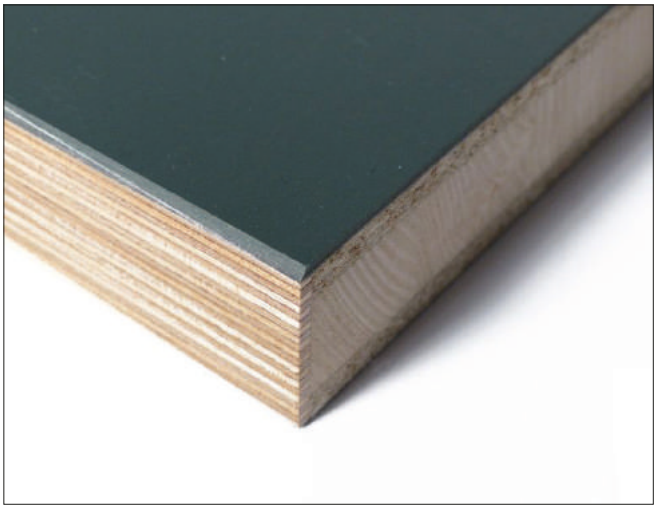
The box is made of basilit processed pinewood plywood of 10mm sheets. To get the correct stiffness in the product proposal the plywood will be joint together with a dowel and glued. Forbo linoleum laminate is chosen to put on both sides of the plywood. This is to make sure the sheets don't budge and to give the aesthetic feel to the product the team desires from the style board at page 54.On the end of the box, a groove is milled and a handle is placed. The handle is in polypropylene (from now on referred to as PP) and is molded. [WS65]



Ill. 184 - Assembly of pinewood plywood connection

LID

The lid is made from the same basilit processed pine plywood of 10mm sheets with Forbo linoleum laminate. In the side of the hinge placement, a groove is milled for the hinges to be placed in as is the counterpart in the box. On top of the lid, a handle is extruded in PP and placed on top grabbing down over the box edge. The handle is milled and screwed on to the lid.



Ill. 185 - Pinewood plywood with Forbo linoleum laminate

TOWER HOLDER, TOWERS, PLUGS AND WATER COLLECT TRAY

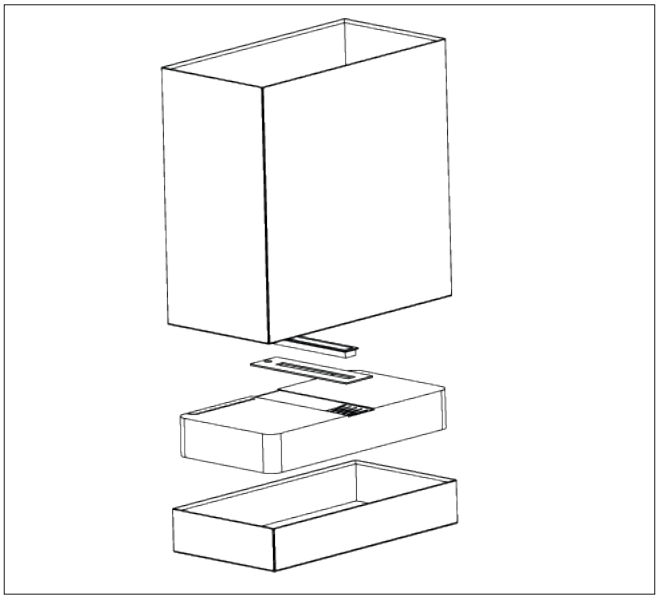
The towers will be extruded in PP and a bottom will glued on. The handles are molded in PP and fastened with a bolt. The tower holder is a cut out plastic sheet with "arms" glued on to hold the towers when inserted. The "arms" are extruded in PP and cut in the right size. The plug holder is molded in PP because of its complex form. The water collection tray is made of plastic and milled to the desired shape.

WATER TANK

The water tank is blow molded in PP. The bottom is angled to steer water down to the pump. Furrows are made in the bottom to make sure the water breaks when the product proposal is moved. A sheet is made and glued on the top of the water tank. A piece is cut out of the upper part to make insertion of the water pump possible.

ASSEMBLY

The product proposal is assembled by putting the grow box on top of the water tank that is placed in the wheel cart. Here a male-female connection ensures water to flow directly into the tank.



Ill. 186 - Assembly dtawing

PRODUCTION AND MATERIAL CONSIDERATIONS

Production, materials and production price have been considered throughout the first concept specification and up until the delivery phase. Therefore a lot of different considerations and iterations on the production methods and materials have been made. This process has been messy and at times hard to get a grip on because design together with material and production gives a whole lot of parameters to keep track on with form, surface, interaction and business. below is some of the process shared in the report to see the whole process see [WS57].

Through the process, the team has made many considerations regarding the production methods of the different parts and what material should be used. In the start the team tried to stay fixed on an all reused PP solution because of the sustainable image of a product should match the capability of growing leafy greens at the site of usage. This was changed to linoleums laminated pinewood because of other aspects such as stiffness in product and interaction [WS65].

For the towers both extrusion and molding was explored as options. Molding the towers could be beneficial when the tooling is depreciated. This was considered and could be a future production method when scaling but as an initial production method for the product proposal extrusion was chosen because of the cheaper startup cost.

All the production calculations are made with an overhead of 25% on top of the traditional cost as tooling, material, man-hours and overall production cost as the startup of the machine and machine cost per hour. To see the whole process of experimenting with production methods and cost see [WS57].

PART	PRICE PER PRODUCT
Box with lid and wheel cart	2700 DKK
Handle on box	270 DKK
Handle lid	350 DKK
6 Towers	400 DKK
12 Tower holders	200 DKK
36 Plug holders	320 DKK
Water collect tray	400 DKK
Water tank	640 DKK
Technical components	3300 DKK
Assembly parts	750 DKK
TOTAL	9300 DKK

Ill. 187 - Production price estimation

BUSINESS STRATEGY

Here the business case considerations will be accounted for. Different business cases and considerations together with a choice at the end for one of the business cases would be most suitable.

When discussing business with the restaurants the first thing the team discovered was what they are willing to use on leafy greens a year. The restaurants spend 6000 DKK a month on leafy greens and they would like to keep it around the same price because they already lose money on leafy greens. But with the value local greens offers, they are willing to spend a little more than today.

Based on this information and the production price 3 scenarios were considered in how much of the market the team could reach with the product proposal. This was with the TAM, SAM, SOM model.[Thebusinessplanshop]
TAM representing the Total Available Market which is every restaurant in Denmark.
SAM represents the Serviceable Available Market which is the fine dining restaurants.
SOM represents the Serviceable Obtainable Market which is the part of the market the team forecast to sell to.

TAM, SAM AND SOM

	Scenario 1	Scenario 2	Scenario 3
TAM	16000	16000	16000
SAM	3200	1600	1600
SOM	320	160	80

Ill. 188 - TAM, SAM and SOM.

The team combined the TAM, SAM and SOM scenarios with 3 different business cases.
These are; Cost + markup, Service-based, and leasing model. All calculation are based on one customer buying four products which is enough to cover all their supply. To dive into the calculations read [WS58].

A Cost + markup business model would not be sufficient. First of all the markup should be greater than the 50% set by the team to get a profit in the best case scenario of 320 customers. Furthermore, the calculations revealed that there is a need for a bigger market if the team will drive all the profit through the sale of products and not service. For this calculation see [WS68].

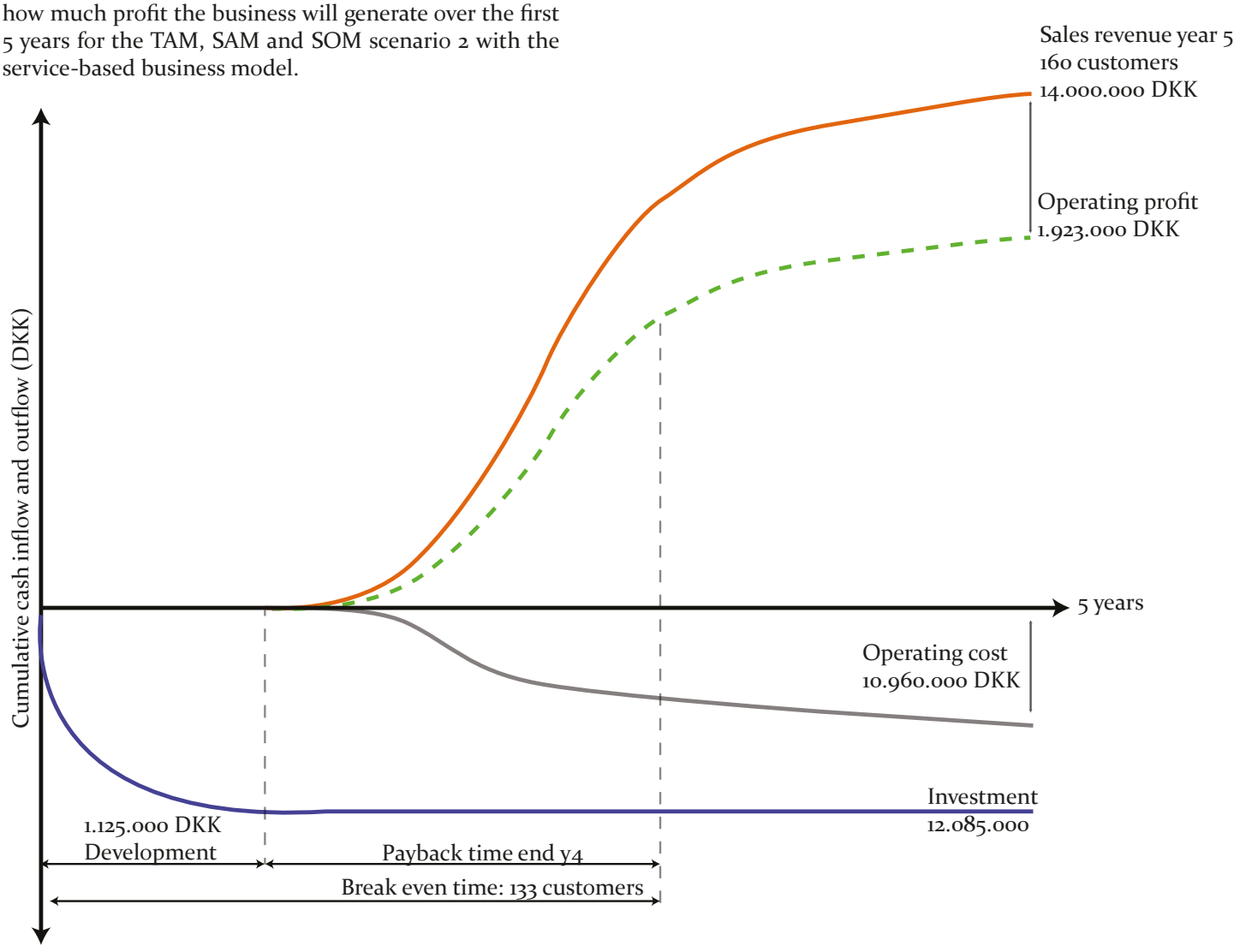
The leasing scenario was calculated and it was discovered that even though it is a great business case for the restaurants when the product delivers 100% of their leafy greens[WS58] it is not sufficient for the team because of its low sale price relative to the product price. The calculations are presented in [WS68].

This leaves the service based scenario inspired by Nescafés business model[Osterwalder &
Pigneur, 2015]. Here the team calculated the profit of scenario 1 and 2 in the TAM, SAM and SOM.
The production, sale price and service price are presented in the table below. These numbers were calculated into the TAM, SAM and SOM scenario 1 and 2.

Production price	Sales price	Service one year
36.000 DKK	52.000 DKK	1500 DKK

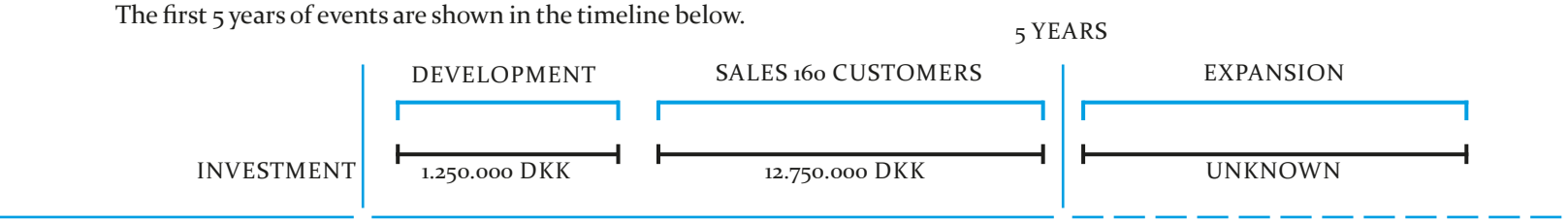
Ill. 189 - Production price, sales price and service price for service based scenario

The team calculated how the business case would look like over a 5 year period. The illustration below shows how much profit the business will generate over the first 5 years for the TAM, SAM and SOM scenario 2 with the service-based business model.



Ill. 190 - Cumulative cash flow

The first 5 years of events are shown in the timeline below.



Ill. 191 - 5 year plan

The first year will be development on the product proposal to get it market ready. Here grow time and technical components will be the main focus. Development will be done with restaurant that can get the leafy greens for free in exchange of sharing experience. For the development phase the team will seek business angels to fund the company.
When production and launch is ready the team will apply for 13.000.000 DKK in funds to produce 640 products; 4 for each customer that can cover 100% of their leafy greens delivery and save them 75.000 DKK over a 3 year period[WS 58].

EXPANSION

When the market in Denmark is settled, it is preferred to bring the product proposal to other markets. The markets in this case needs to be similar to the ones in Denmark. This means that the other countries also have to import leafy greens. Northern europe and especially Norway, Sweden and the United Kingdom struggle with the same issues as the one the Danish market has. Therefore an expansion to these markets as the next step would makes sense. When expanding the companys strategy needs to be iterated on before implementing. Service and maintenance could be redesigned and therefore a test expansion could be set in place before a real expansion. This is to test how the market is in these other countries and how they react to a product like this.
This could restructure the whole cost/price setup and therefore a test would be needed to see if the business is viable in other countries.
With time hydroponics and the future of urban agriculture will be more present and therefore the market will be more ready for such a product. This means that in the expansion strategy a loss in the beginning could be a method to ensure a share of the northern europe market.

RISK

Selling enough vs return: In all investments there is a risk of not getting a return of investment. In the case presented there is a return of 20%. This is with all units sold and nothing left. If the sold numbers comes below 133 customers the business case will be critical and the investors will lose money. The team has made 3 scenarios where the one presented was the one with the medium investment. A scenario was made with minimum investment and 80 customers but the calculation revealed that for this to work one must make the business case different than what is here experimented with. The last scenario showed a larger investment but also a higher return rate of 33%. To read more into the payout from investment see [WS68].

Customer reaction: It is difficult to know how the market will react until you face it. Therefore some considerations on how the market can act differently than assumed was made.
As of now, the business case is made upon a strategy where the team provides products and service to cover 100% of the delivery of leafy greens to the restaurants. A risk here is the restaurant being hesitant with buying for 100% delivery and instead is buying to trying out and thereafter implement it in their supply chain of foods. If this is the case the business case will look completely different and could pose a threat to the overall concept.

Service as the main revenue: The business case chosen is the one which showed the best numbers. It is also the one with a service as the main element. The service can be critic as a service is easy to replace with other services. Here the team needs to be aware of the potential risk of providing a service and how to protect itself from other competitors in this field or the restaurant doing it themselves. Therefore a strategy for protection is discussed.

PROTECTION STRATEGY

To protect the design different options for further development on the product proposal was discussed.

Patent: First and easy a patent on the plug holder can be made to ensure the restaurants can not use other products to grow leafy greens in the product proposal. The downside with this proposal is that even though the patent initial cost are high, the legal fees protecting this patent might be higher and therefore very costly for a startup. Therefore other solutions was discussed.

Producing plugs to only fit into the product proposals plug holder: By changing the design from the original plug and make it only match the teams plug holder the team can have an advantage over potential competitors by making sure it is only the teams plugs that can be used in the product proposal, thereby the restaurants must keep the service and therefore not look elsewhere.

EVALUATION ON DEMANDS

Design demands have been used during the project in order to develop a product proposal which solves the found challenges. Demands have been added and removed during the process as the project unfolded and got more clear. Due to priorities and a limited time frame, not all demands has been specified or solved completely.

PAGE NO.	DEFINED DESIGN DEMANDS	STATUS	HOW?
16	Produce 4 kg leafy greens per week	✓	Acetarium produces 4,5 kg of leafy greens every 3 weeks, with 4 Acetariums there will be more than 4 kg. per week.
16	Should match the price of greens today	✓	With 100% yield, the restaurant will after 3 years have saved approximately 75.000 DKK on acquiring leafy greens.
16	Grow usually imported greens	✓	In Acetarium there can be grown leafy greens such as spinach, arugula, batavia and so on which is usually imported.
23	No need for packaging	✓	It is designed so direct harvest at the usage site is possible.
25	Should be a controlled environment	✓	Acetarium provides a closed environment.
43	Moveable	✓	Handles are placed both on the side and on the front for moving around. Four wheels are mounted on the bottom.
52	Opportunity for day to day harvest	✓	If set up properly where the user harvests and seeds every day then there will be leafy greens ready for harvest every day.
53	The plug should have nutrients in	✓	Coco coir plugs are rich in nutrients.
53	Grow medium should allow water flow and air flow	●	At Nabo Farm it is proved to work, but it is not confirmed by the team.
55	Semi-automatic watering system	✓	The watering is automatic as long as the user fills the water tank once a week.
55	Seeding in one motion	✓	The seed is placed in a groove in the plug.
55	The lid should close softly	✓	The lid has resistance in the hinges.

PAGE NO.	III-DEFINED DESIGN DEMANDS	STATUS	HOW?
16	An integrated solution to the restaurants	●	It is an independent product proposal. It is placed in the restaurant context but it is not " a part" of the interior.
16	Reliable delivery	✓	In theory, the product should deliver a reliable yield. The concept is proven by Nabo Farm.
20	Should be plug and play	✓	After assembly the power is connected, water is filled on and Acetarium is turned on. From there everything runs.
20	Should be able to change the amount produced based on demand	●	More than one box will give freedom to grow the wished amount. Also, the user can choose to plant less. But it is not the intention.
23	Integrated into storage scenario	✓	No need for storage when it is already "stored" in the box. It is harvested when needed.
27	Equal quality as locally grown vegetables	✓	In theory and according to Nabo Farm it is at least as high quality as locally grown.
27	Less time consuming than own farm setup	✓	Minimum maintenance, just seed and harvest, no weeding, pests and pesticide.
37	Should offer modularity	●	You can buy more than one. But Acetarium is not stackable.
37	Be able to place both inside the kitchen/basement or at a dining patio	●	Nothing to control temperature other than light and ventilation which is enough for inside, but it is not validated for outside.
43	Germination should be in the product proposal and not separate as today	✓	Plug holder is angled 45 degrees to hold the seed in place until roots are fastened.
43	Should be able to be placed together to minimize space waste	✓	Acetarium has a square form which ensures less space waste in between the boxes or other furniture.
46	Should be able to move up and down stairs	X	It can be carried in parts but it is heavy. Otherwise, it is not optimal to carry.
52	Feedback as a tool to get critical information	✓	Sensors provide feedback to the user about critical issues if water and power turns off.
53	Grow medium needs to be kept wet	✓	Drip system provides more than the needed 0,66L for each tower every day to make sure the grow medium and plug is always wet
55	Expression should be simple, dark colors and defined strict shapes	✓	The material and form are rated to fulfill the expressions from the style board.
55	Lightweight tower	✓	It depends from person to person, but in the user test at [WS60], it was not an issue.

X Not fulfilled ● Partially fulfilled ✓ Fulfilled

PAGE NO.	INITIAL DESIGN SPECIFICATIONS	STATUS	HOW?
46	Should be no more than 90 cm tall	✓	The whole Acetarium is 85 cm tall.
46	Should be no more than 50 cm deep	✓	The whole Acetarium is 37 cm deep.
46	Should be able to move over a 2,5 cm edge.	✓	The wheels are soft and 7 cm tall.
46	Should not be affected by being placed on a uneven surface 2-3 degrees	✓	The water tank is angled at 5 degrees in the bottom to steer water down to the pump.
52	One product proposal should produce 1 weeks worth of leafy greens	✓	One box can produce approximately 4,5 kg leafy greens. Note that the kg. can slightly vary due to the type of leafy greens.
55	Automatic ventilation system	✓	The fan will blow 2 hours a day divided out on approximately 5 minutes per hour.
55	Time controlled light	✓	The light will turn on for 18 hours and be turned off for 6 automatically.

CONCLUSION

This master thesis was based on the theme of Urban agriculture where it was discovered that restaurants have problems regarding their supply chain of greens. The restaurants use 6000 DKK a month on receiving unsatisfying leafy greens imported from southern Europe. These greens are often damaged and has lost nutrition and taste. The restaurants are depending on these greens to make their courses and therefore often have to cope with this issue by establishing own agriculture or not informing the customers about what type of leafy greens are used. Throughout interview, observation and testing concepts, the team has come up with a product proposal to produce 4 kg leafy greens in the timespan of three weeks to challenge the restaurants reliance on imported greens.

The product proposal called Acetarium is developed to service the restaurants with their own locally grown leafy greens. One Acetarium is producing 4.5 kg every third week. Observed restaurants use approximately 4 kg a week which means the restaurants needs four Acetariums to cover their total usage of leafy greens. Acetarium is placed under the kitchen work tables or outside, here it is plugged into power and runs by itself. The restaurants get the seeds, plugs and nutrients from Grow4 and handle the process of seeding and harvesting themselves. The seeding process is done in Towers where 6 leafy greens can grow. One Acetarium has 6 towers. Seeding is done by placing the seed in the coco core plug and placing the plug in the plug holder. The plug holder is slid into the tower with a plastic based grow medium for the roots to grow in and the tower is placed into Acetarium vertically. From here the growing process begins. Growing light are faced towards the towers and are controlled to ensure optimal growth.

The leafy greens are watered with nutrient rich water through a drip system placed above the towers, taking water from the water tank placed below the growing box. This process is automated and a sensor system is controlling if something goes wrong with the water flow or power, in which case it will inform the restaurant. After three weeks the leafy greens are ready to be harvested and are either stored in the cold storage room or used directly in the courses. Here the tower handle acts as a device to angle the tower laying horizontal on the worktable to ensure no leftover water from the grow medium leaks out on the table. When harvesting the user can seed again and the three-week process starts over. Acetarium is made to be moved around by one person with a handle on the lid to open the product proposal and to move out from under the worktables. A handle is placed on the end of the product to ensure easy movement around the restaurant and over door edges.
Four Acetarium costs 52.000 DKK and a service fee of 1.500 DKK a month to get seeds, nutrients and plugs and maintenance if there is a fault in the product proposal. This business case was chosen because it makes a profit for Grow4 and benefits the restaurants economically as well as getting a better leafy green product.

From the start when focussing on the restaurants the team wanted to grow microgreens for the restaurants as well. This was later deselected as a design demand because of the importance for the restaurants. They saw herbs as a better secondary product and therefore microgreens was deselected and leafy greens became the main focus to solve.

REFLECTION

Even though the team have reflected upon actions throughout the process report and in worksheet a reflection on the whole project and its most critical points is made. This master thesis have not been without its hurdles therefore a general process reflection and more in depth reflection are presented here.

GENERAL PROCESS

The general process in this project have been characterized by the teams ability to use logic before experimenting. A lot of development process was in the beginning controlled by logic and what seemed on first sight to make sense according to the demands and insights gathered. This led to an insight late in the process of not having unfolded the solution space enough and therefore led to a more fuzzy process than what could have been.
The amount on time spend throughout this project on meeting dead ends and waiting on potential problem owners and stakeholders could have been minimized in knowing the subject better before diving into it. Here the team chose to be stubborn even though a pivot was considered a month in the project due to a hard time finding experts to talk to.

MISSING ACCESS AND KNOWLEDGE

The project started out with a vision of looking at private apartment owners need for a garden and later the future of agriculture. This part of the process was time consuming and frustrating. Access to potential problem owners and stakeholders in this world was hard to get and therefore a lot of time was spend without a great return. This time could have been spend on more in-depth discovery or develop phase if the team had settled on restaurants earlier.
Acces was an issue and especially on the technical side of making a hydroponic product proposal. The business of growing leafy greens inside in Denmark is young and therefore not established properly yet. Even though the team found access in Nabo Farm and other in this field the companies are not willing to share nutrient mix, light setup, air and water flow information. This has limited the team in developing concepts because these technical aspects have been hard to implement properly.

THEORY APPLICATION

The HETI model [Blank & Dorf, 2012] have been the foundation of the worksheets and how the team have been working with gathering data, creating new insights and testing the insights in a loop. In the development phase of this project the team suffered from thinking too concrete and not using this model to open up the solution space and experiment more with the gathered insights to test different solutions to the problems faced. Even though it was realised an acted upon in the development phase the overall process still suffered from a too late opening of the solution space.
This can been seen in the placement of different technical components in the product proposal and the locking mechanism of the assembly of box, water tank and wheel cart.

TO WORK WITH ALL ASPECTS AT ONCE

The ability of working with design as a integrated subject with aesthetic, construction, production, function, interaction and materials have in some instances not been present in the design phase. Exampliary in the development of moving the product, production and weight in the water tank. Here the team did not work with all the different aspects of design at once but more separated into themes. This resulted in a substantial change in the production and material in the end of the development where the team did change the outside components material from polypropylene to pine plywood with linoleum laminated on. Insights like these were made late in the process and therefore a sprint was set in to catch up on the loose ends the team found most critical. Here the team learned the hard way to integrate all the different aspects early on in concept and do it parametric to control the process more.

TESTING LIMITATIONS

The Interaction with plants has been hard to simulate. This is because a growing cyclus from seed to harvest according to the urban agriculture business are three weeks but the team had a hard time replicating this because of the surroundings. Therefore interaction of plants and product proposal have been investigated minimum. This can have led to some interaction problems when harvesting or tower interacting in the product proposal is theoretically. The team have made grow experiments to determine germination process in the product proposal and to validate things such as the importance of controlled environment and light but the yield have been minimum and therefore hard to test with. Here the team have made assumptions based on the insights observed and not what they have experienced.

RELEVANCE

With all that said the team is convinced that urban agriculture is going to be a part of the future. And solutions as Acetarium with small space hydroponic systems will be more common in our society within the next decade. The problem found is relevant for the challenges we as humans will face in the near future where restaurants is assumed to be the first movers, they are already trying. As a product proposal to solve this problem Acetarium could be the solution, even though it is not finished and tested properly, the proof of concept has already been made by others such as Nabo Farm, whereas the technology applied in Acetarium is already used with success in other products.

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ILLUSTRATION LIST

All illustrations not mentioned in the illustration list is made by the team.

Ill. 4 - Discover introduction - https://www.tapinto.net/events/spring-gardening-series-starting-plants-from-see
Ill. 10 - Nordic harvest logo - https://www.facebook.com/NordicHarvest/
Ill. 11 - BIOARK logo - http://www.bioark.dk/
Ill. 12 - Nabo farm logo - https://nabofarm.com/
Ill. 22 - Traditional agriculture - https://www.pexels.com/es-es/foto/731502/
Ill. 24 - Notation of ala carte court at Fladbro Kro - https://www.fladbrokro.dk/restaurant-fladbro-kro-randers/frokostmenu/
Ill. 26, Ill. 45 - Define introduction - https://www.almanac.com/image/seedlings-1
Ill. 27, Ill. 53 - Deliver introduction - http://sciencefuture.net/vertical-farms/
Ill. 46 - Farm shelf for growing at the restaurants - https://www.farmshelf.com/
Ill. 47 - Citycrop for smaller indoor growing - https://www.citycrop.io/order-your-citycrop-old/
Ill. 48 - Zipgrow for indoor growing on limited space - https://zipgrow.com/pages/educational
Ill. 49 - Four different hydroponic systems - http://www.nosoilsolutions.com/6-different-types-hydroponic-systems/
Ill. 63, Ill. 64 - Coco coir and Rockwool - https://www.epicgardening.com/hydroponic-growing-media/
Ill. 65 - Zipgrow matrix media - https://imgbin.com/png/zwZYfk1f/organic-food-organic-farming-urban-agriculture-organic-horticulture-png
Ill. 69 - Expression: Simple on the outside - https://unoliving.no/flexa-cabby-opbevaringsmodul-m-1-kasse
Ill. 70 - Expression: Rounded edges - http://blog.livedoor.jp/bluejay01-review/archives/54711055.html
Ill. 71 - Expression: Durable - https://bit.ly/2MikjKx
Ill. 72- Expression: One piece - https://www.flinders.nl/outlet-42c6229727ffc268370b49536173be06
Ill. 73 - Expression: Strict curves - https://www.pinterest.dk/pin/28499410125319972/?lp=true
Ill. 75 - A liter of milk - http://nyheder.tv2.dk/article.php/id-7907692%3Alandm%25C3%25A6nd-i-k%25C3%25B8-for-at-droppe-arla.html
Ill. 76 - Golfball on a tee - https://pixers.dk/plakater/narbillede-af-golfbold-pa-tee-pa-golfbane-57994950
Ill. 77 - Toilet seat - https://laughingsquid.com/smartnudge-device-automatically-closes-toilet-seat/
Ill. 78 - App on phone - http://globalhealthpartners.com/
Ill. 79 - Hand watering - https://www.pinterest.dk/pin/342555115404180259/?lp=true
Ill. 80 - Opening a window - https://www.pinterest.dk/pin/11892386494411890/?lp=true
Ill. 81 - Energy from the sun - https://www.pinterest.dk/pin/384424518166215180/?lp=true
Ill. 82 -Automatic sprinklers - https://international-agriculture.com/angolan-staff-training/
Ill. 83 - Using air-condition - https://apexautoclinic.com/ac-heating/
Ill. 84 - Using focused sensors - https://www.pinterest.dk/pin/671388256926481966/?lp=true
Ill. 172 - Deliver introduction - https://bit.ly/2W6Fcbg
Ill. 173 - LED strip for optimal growth - https://www.amazon.com/Light-Plant-Strips-Indoor-Plants/dp/B07FCGJK9W?fbclid=IwAR10QDdHge_uqqDTD08zoj6OVyPpucLYB-BwYawwd3QGb2Kva6Ixo8yaJ4k
Ill. 185 - Pinewood plywood with Forbo linoleum laminate - https://www.pinterest.dk/pin/147563325271357331/?lp=true

ACETARIUM