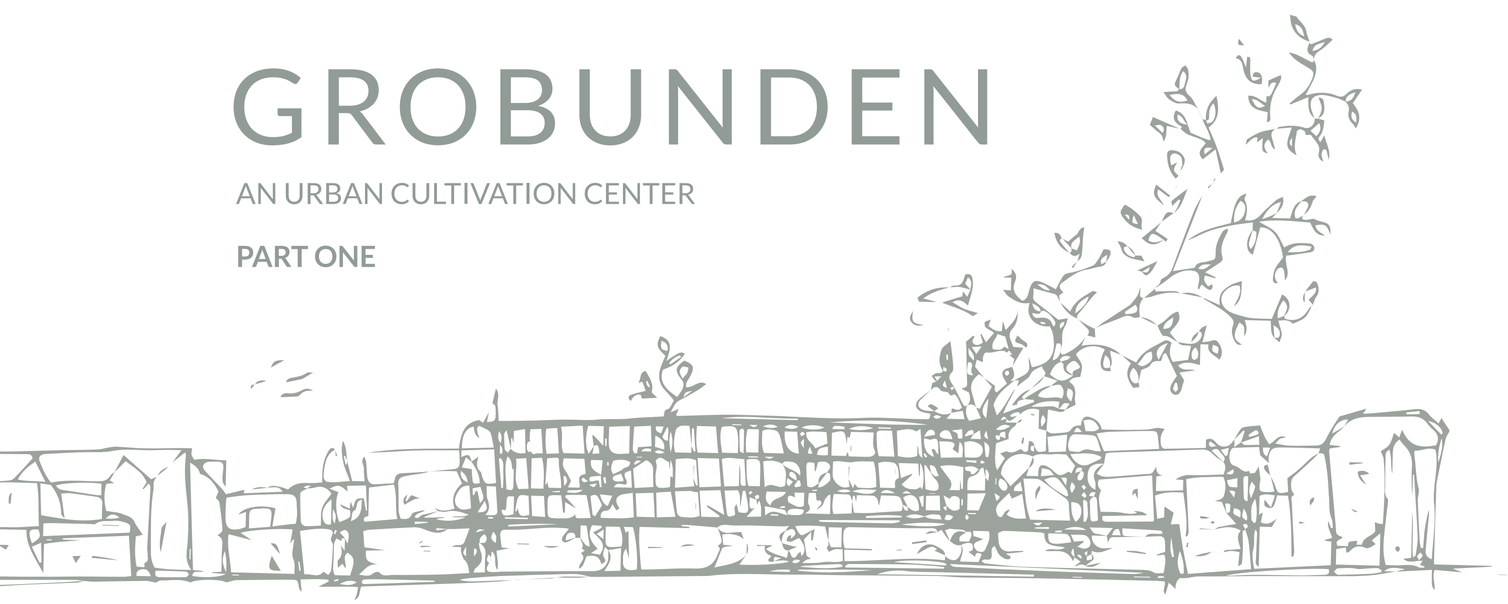
GROBUNDEN

AN URBAN CULTIVATION CENTER

PART ONE



GROBUNDEN

An Urban Cultivation Center in Aalborg

Project title:	Grobunden
Semester:	MSc04 – Architectural Master Thesis
Group:	22
Main supervisor:	Tenna Doktor Olsen Tvedebrink
Co-Supervisor:	Endrit Hoxha
Project period:	01.02.2023 – 26.05.2023
Institution:	Aalborg University
Number of Copies:	6
Number of Pages:	53
Authors:	Karoline Marie Petersen
	Kasper Brøndum Kristoffersen
	Pernille Løkke

Abstract

The following master thesis represents a proposal towards a future development of a hybridization of modern agriculture and urban cityscapes.

The thesis presents the potential of utilizing and transforming an urban monofunctional parking structure into a multifunctional cultivation center which regenerates the space into an urban catalyst in the city of Aalborg.

It explores and investigates how we can integrate sustainable and innovative cultivation techniques to serve the practical purpose of providing food, while encouraging to rediscover the infrastructure of modern food systems through food literacy related programs.

Reading Guide

The following report contributes PART ONE of a two-part thesis, where the following represents the final design proposal of the constructed problem statement. The report consists of the outcome from a longer design process, presenting plans, sections, and visual renders of the project.

The second part provides the content of the theoretical background of the problem, site analysis with following early investigations and lastly an in-depth design process leading up to the outcome of this thesis design proposal.

01

PRESENTATION 6.

Problem

Due to a continuously growing population and an increasing rate of urbanization our natural resources are under pressure as our untouched land is being utilized for agricultural purposes to feed us (Ritchie, 2018). These complex challenges demand a change in how we develop our cities in the future.

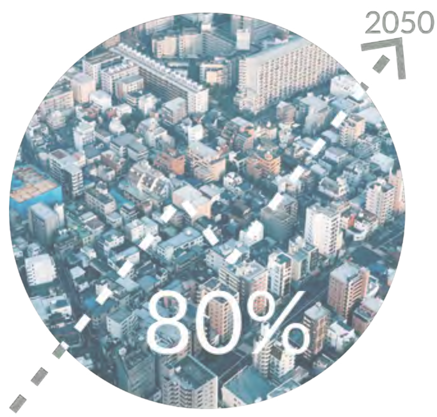
The built environment is of fault for the scarce resources today, as we have created an unhealthy and generic building tradition, where materials and the characteristics of the buildings are copy pasted, causing a lack in the experience, the atmosphere, and the wellbeing of living in these.

Furthermore, cities like Aalborg are already relatively dense but there are still voids or wasted spaces, full of potential which need to be re-purposed and designed and make them re-inhabited to be used.

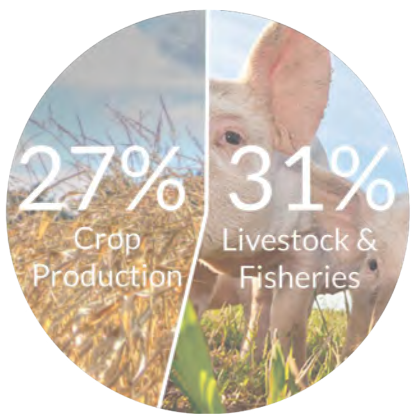
Habitable **land is used** *for agriculture globally. In Denmark 66 % surface is used for agriculture.*

Deforestation *has a detrimental effect on the biodiversity, herbal ecosystem, and nature.*

World Population *is increasing, In Denmark there are currently 5910.577 people.*



Raise in **urbanisation**.
In Denmark 23 % of the population lives in the capital.



Traditional Agriculture accounts for one quarter of the global greenhouse **gas emissions**.

Green produce **travels** *upwards from origin to consumer.*

Illu. 1: Pie charts diagrams

Opportunity

The thesis will investigate the opportunity to address these issues through a hybridization of the built environment and new approaches relating to cultivational design. By integrating the dynamics of our ecosystems into the cityscapes we can change our traditional ways of production to consumption and create an experience for people to see, try, and taste the dynamics of our food system of growing, harvesting, buying, preparing, and eating. It is the physical interventions which alter metaphysical perception.

In addition, there is a big climate friendly potential in utilizing existing spaces in the city. An alteration or a re-purpose of the built environment can become part of the future for the new place, resulting in an elongated lifespan. Architecture has the potential of being a catalyst in the urban setting, through its aesthetics and programming as it can influence and promote interactions and life inside and around it. .

Setting

The 11-year-old two story parking lot in Sauers Plads, central Aalborg, is currently only meant for parking (Termansen, 2012). It takes up a big plot of a central area of the city that is surrounded by apartment blocks, a local police station, fire station, health center, stores, and a park. The raw concrete construction stands as a "wasted space" meaning that it has the potential to be much more than just a parking lot and serve more purpose for the local area as well as to the city of Aalborg.

Therefore, this setting will constitute as a platform to investigate how basic daily architecture in an urban space can promote a change both socially and physically by adding meaningful architecture that can promote knowledge and experiences to the daily, weekly, occasional, and seasonal visitors of Aalborg.

Intention

This thesis explores and investigates how architecture can address the global food crisis and issues related to traditional agriculture through the potential of using modern cultivating methods and existing urban wasted spaces, here the aim is to start addressing the problem by creating an urban cultivation center in the city of Aalborg.

To enhance the knowledge surrounding food, the building will act as a center with functions related to and focusing on sustainable agriculture, nutrition and health, food, and social equity and sustainability.

Furthermore, through an environmentally sustainable approach, the thesis will explore how the use of materials can enhance the atmospheres of spaces, like using waste from the cultivation methods as building materials and enhance expressive qualities and at the same time serve the practical purpose or minimizing the carbon footprint of the building.

How can urban cultivation methods be integrated in existing cityscapes, to support food security for the rising population in the cities, and act as a new catalyst for a social- and food literate typology. ?

Grobunden

Rooted into the urban parking house of Sauers Plads in Aalborg, the sprouted Grobunden stands sturdy, contributing as a new catalyst to the city. The monofunctional parking lot has been transformed into a multipurpose innovative cultivational center, where the built environment contributes to a resilient smart solution towards a more sustainable and efficient food system for growing fresh produce within the city scape.

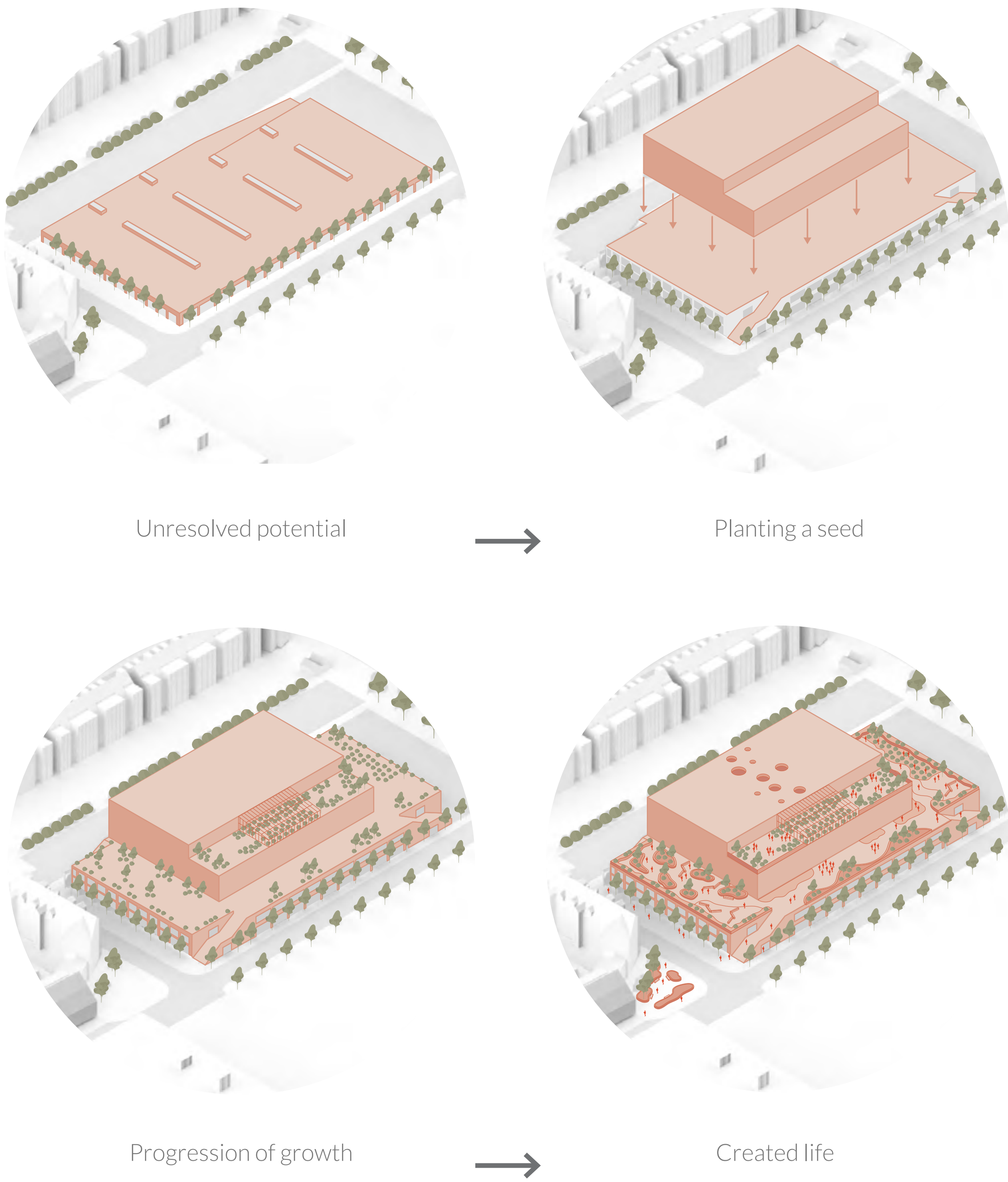
Grobundens distinctive green and vegetated facades creates a modern architectural building that translates the typology of an urban cultivation center. Through its shape and scale, it respectfully considers its placement and surroundings and acts as a public space to the locals.

The cultivation center revolutionizes new ways of incorporating food production into existing urban areas, through the use of innovative techniques. The incorporation of vertical hydroponic systems, mushroom farms and microgreens generates a more sustainable and equitable future, regardless of the weather as these climate-controlled productions ensure year-round crop yields.

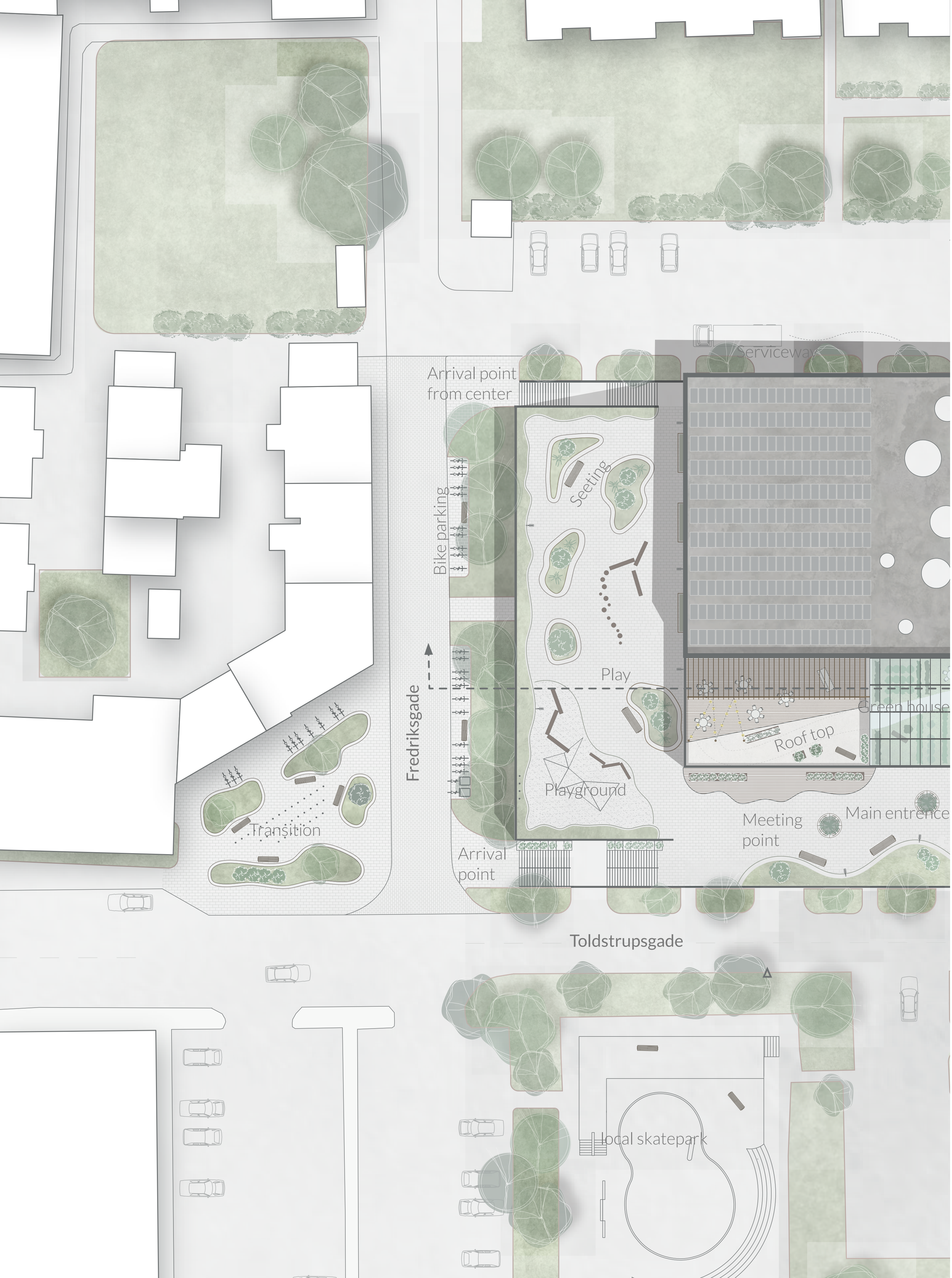
Through its food related program, the center cultivates food literacy, by providing educational opportunities for the visitors to learn about the sustainable methods of vertical farms and food culture. Furthermore, the center acts as a community hub, by inviting visitors and locals in to join various food related activities.

Grobunden prioritizes environmental and energy efficient practices by utilizing renewable energy sources to generate energy to supports its artificial ecosystem. The symbiotic cycle of the ecosystem reuses elements from the productions and reduces food waste through its composting. Through its carefully selected materials it contributes to a more carbon light development.

The new cultivation center encourages visitors through food literacy to grow, spread and use their knowledge of the cultivation methods within their home and community.



Illu. 2: Concept diagram



Serviceway
Arrival point
from center
Seeting
Bike parking
Play
Green house
Roof top
Fredriksgade
Playground
Transition
Meeting
point
Main entrence
Arrival
point
Toldstrupsgade
local skatepark

Masterplan

The implementation of Grobunden creates a roof garden in extension of the existing park. This urban space is programmed to offer different activities such as a community garden, outside seating, and space for relaxing. A change in the pavement addresses a variety in the different zones such as the play zones, where kids can play safely from the street below.

The main entrance is located in the center of the southern façade surrounded by the shop on the west side and the café on the east side. Each function expands outside, enhancing the outdoor life and experience. The café is wrapped around the corner with outdoor seating and has views of the play area, the community garden, and the main entrance.

Illu. 3: Masterplan 1:500

Program

The program of Grobunden serves various food related functions and activities consisting of:

Food Security

Community Farms
Area: 450 m^2

Green House
Area: 215 m^2

Food literacy

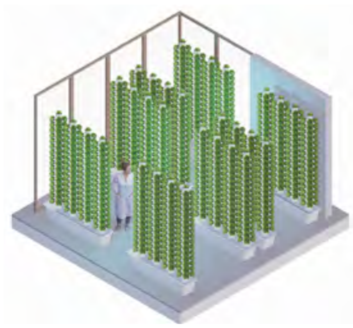
Workshops
Area: 305 m^2

Cooking class
Area: 200 m^2

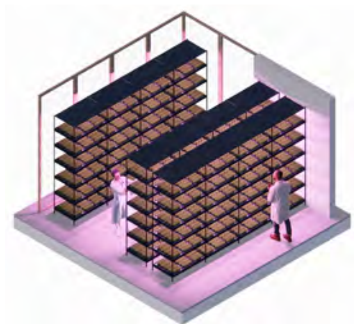
Catalyst Architecture

Shops
Area: 102m^2

Cafe
Area: 290 m^2



Hydroponic Farm
Area: 595 m^2



Microgreen Farm
Area: 110 m^2

Mushroom Farm
Area: 155 m^2

Social Dining
Area: 320 m^2

Exhibitions
Area: 710 m^2

Playground
Area: 280 m^2

Social Spaces
Area: 580 m^2

PROGRAM OF GROBUNDEN

TOTAL AREA OF: 5360 m^2


A
B

Illu. 4: South Elevation 1:250

The Apperance of Grobunden

The facades of the new cultivation center translate the typology through the green stucco cladding which is almost camouflaged by the green vegetation growing on it, whereas only the warmth of the wood from the slats are peeking through the vines of the plants.

The simplicity of the façades expresses the number of levels on the inside through the horizontal beams. While the vertical lamellas emphasize the verticality of the building. The material contrast of the green and the slim profiles of the slats supports a lighter appearance of the compact building. The structural system and the honesty of the construction manifests through the reinforced concrete columns.

The reinforced concrete has been retained to enhance the appearance of the parking entrees and to visually clarify the transformation it has undergone, from being a grey urban parking island to a green and lively multifunctional space. The new wooden slats on the existing parking facades have been implemented to accommodate new vegetation, while making a relation to the new building.

The southern elevation has an open and inviting expression, through its transparent facades. Whereas the western façade provides a glimpse into the vertical farms through its aligned fenestrations.

Illu. 5: West Elevation 1:250

The eastern elevation has fenestration over the parking ramps which contributes to a visual connection from visitors arriving by car to see into the green production. The northern façade creates a tucked-in covered roof terrace, which lightens the otherwise closed façade. The fenestrations in the building adjust to the slats which emphasize a clean and symmetric rhythm in the lines of the frames of the façade.

Illu. 6: North Elevation 1:250

Illu. 7: East Elevation 1:250

Fredriksgade
Service
Garbage disposal
Compost
Tech
Tech
Fredriksgade
Hydroponic production
Toldstrupsgade

Parking Level 1 and 2

Integrated in the shafts of the existing parking house, visitors by car are met by the glow from the vertical farms. Different vegetables such as microgreens and salads from hydroponic farms grow in these spaces where the lights from the artificial farms provide a purple/bluish glow lighting up the parking house in the evening.

Here is also where the buildings' compost, garbage disposal etc. are placed due to the practicality of the service access's placement.

In the street scape a smaller transformation of Frederiks street and Saures Plads provides a safe transition between the built environment and the street. Here pedestrians can move safely towards the building or park their bikes along the edge of the pavement.

The smaller stairs around the parking house provide easy access to its different floors whereas the big ones lead visitors up to the center.

Illu. 8: Parking level 1 1


Tech
Tech

ch

Illu. 9: Parking level 2 1

Arrival up to Grobunden

When arriving up the stairs to Grobunden, visitors are met by a lively urban plaza. People sit and enjoy the views of the green structures and flowerbeds or people walking by. The scent of fresh air and herbs comes from the community garden nearby, where people are taking care of their own vegetable gardens.

In the periphery children's laughter can be heard from the playgrounds, while the parents are conversating and enjoying their fresh lunch from the café.

The movement of people on the rooftop terrace is visible from the ground floor of the plaza sparking a curiosity of what might be going on up there. Furthermore, the opening of the façade leads visitors towards the welcoming main entrance. Through the façade's transparency, the functions of the first floor are easily read from the outside.

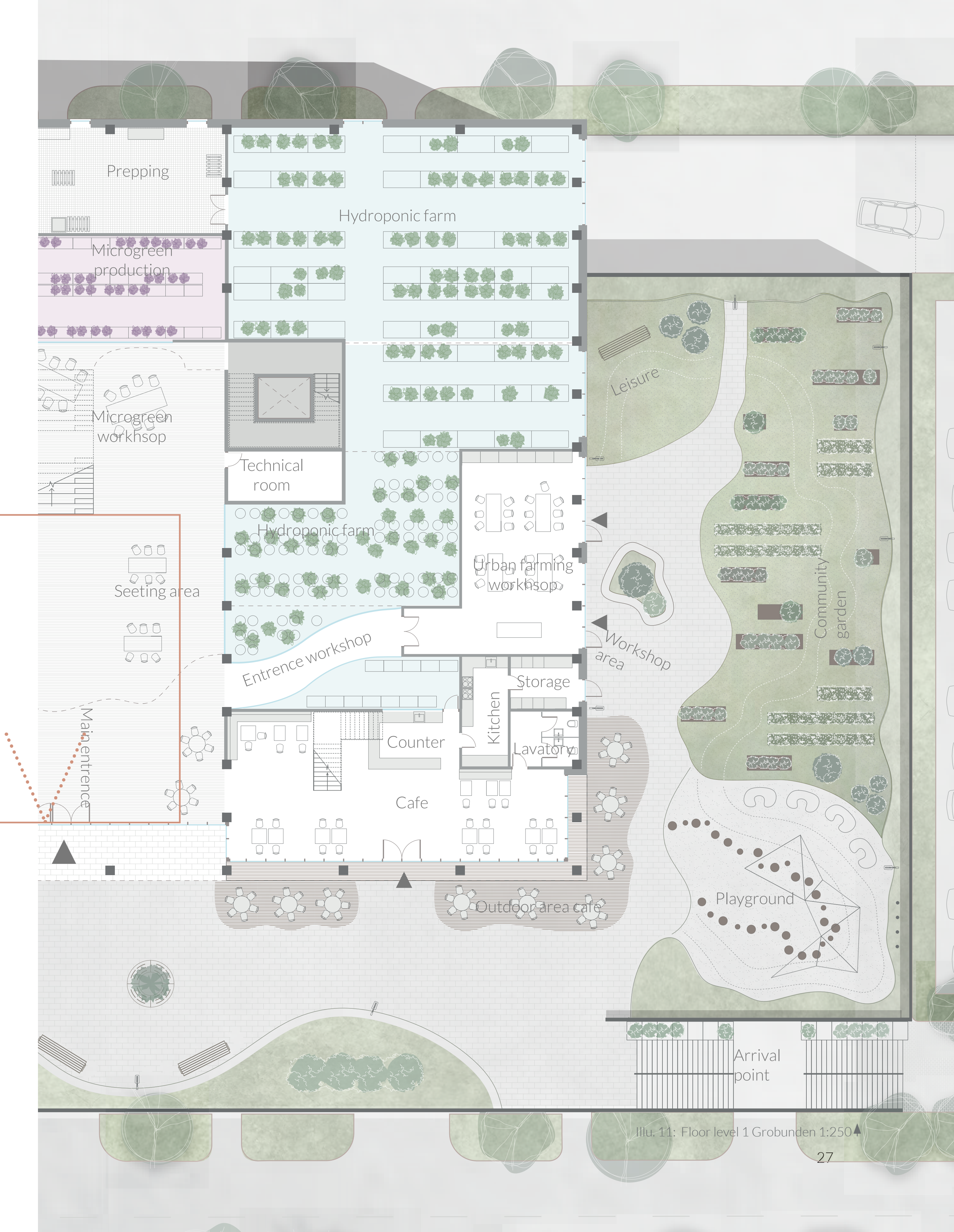
Illu. 10: Eastern arrival point

First Floor

The functions on the first floor of Grobunden, contribute to the daily pulse of the building. The open atrium and facades create connections to the outdoor and indoor spaces. The flexibility of the atrium ensures opportunities for social gatherings and events while at other times lets the surrounding functions melt together in the open space.

Located towards the northern part of the, is the production area and service space for the microgreens and hydroponic farms.

The curvy and transparent entrance which leads the way into the urban farm workshop contributes to a feeling of walking in between the greens. The workshops open façade makes it possible to utilize the space outside.



Illu. 11: Floor level 1 Grobunden 1:250

Atrium

Entering the cultivation center, visitors are met by the pulsating and lively atrium. The open space provides easy observation of its many programs, such as the farmers shop, where daily visitors can buy new seed for their microgreens, or freshly harvested vegetables directly from the center. The main stairs are placed centrally, and the integrated seats invite gatherings or talks while it leads up to the next experience of the center. In the back of the space the purple lights drag visitors' attention to join the microgreen workshop.

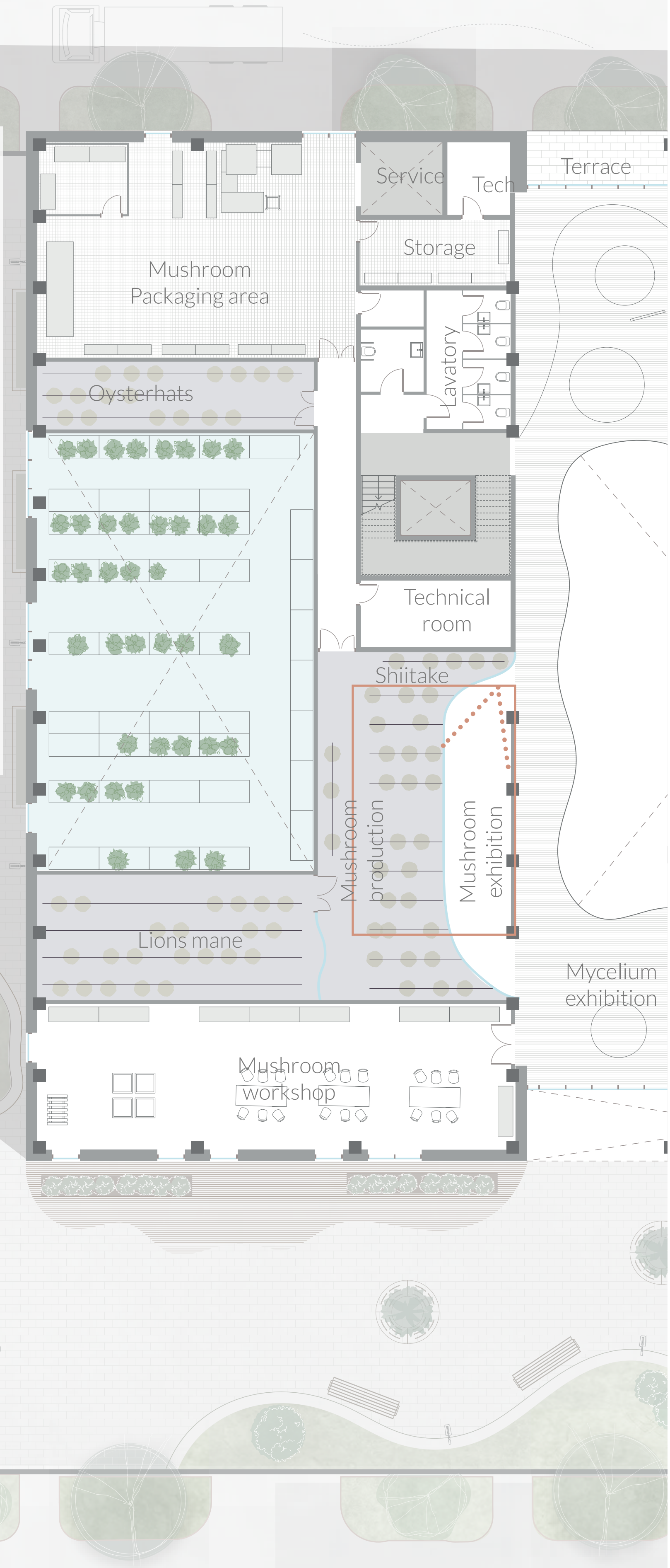
The changing flooring material supports a change in the flow and zones of the large space, contributing to differentiating the café's dining spaces and the flow of the room. All around the space is a visual connection into the different green productions.

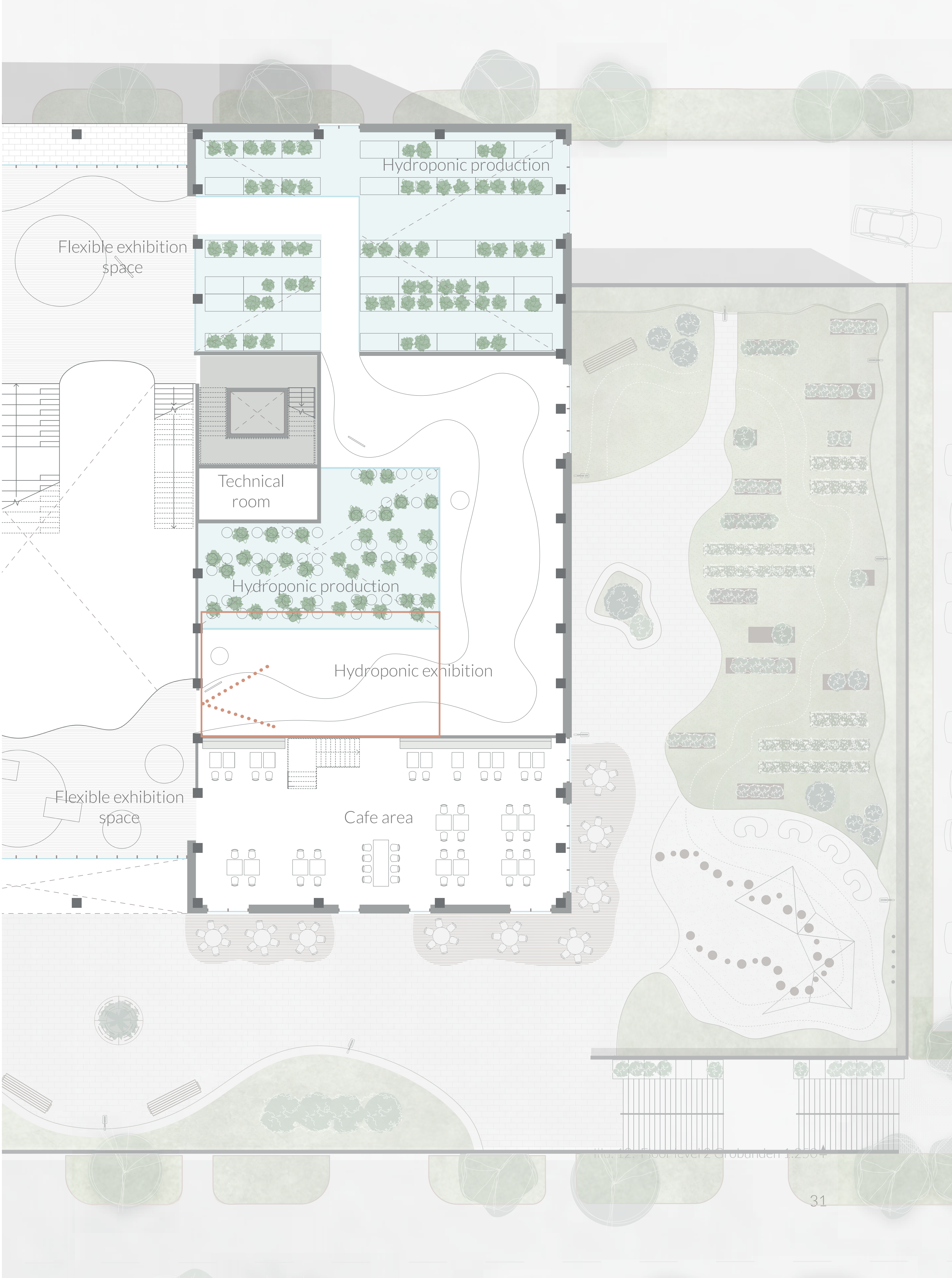
Second Floor

Moving up through the main stairs, visitors enter the first exhibition area, where they will follow the winding course into the mushroom production and its related exhibition.

Followed into the mushroom workshop where visitors can join and make their own mushroom kits from recycled milk cartons and coffee grounds provided from the café.

The second exhibition area is found besides the café area, where the current exhibitions provide knowledge about the use and making of mycelium materials from the production of mushrooms. In the eastern part of the building, with inspiration from Carlo Ratti´s Hortus pavilion, is the hydroponic





Illu. 12: Floor level 2 Grobunden 1:250

Mushroom Exhibition

Following the winding course into the production of mushrooms visitors are met by living walls of mushroom organisms. The curtain lamellas in the ceiling move lively in the breeze and represent the lamellar of the mushroom enhancing the tactility of the space. The mushroom production is closed off by glass, which provides a visible connection into the hanging mycelium bags. The materials enhance the atmosphere through its biobased mycelium panels on the wall, and the warm wood on the floors.

Illu. 13: Mushroom Exhibition

Hydroponic Exhibition

The hydroponic exhibition contributes to an interactive food literate experience, where visitors are moving though the progression of growth. By planting a seed, they can digitally follow the growth of their planted seed until harvested.

The atmosphere of the space provides a future-ish sensation as the purple glow from the hydroponic production glows out in the room. The production is closed off but is visible for visitors to perceive through the transparency of the glass.

The robust material on the floor underlines the function of the spaces as it can tolerate a splash of water from the growth tables.

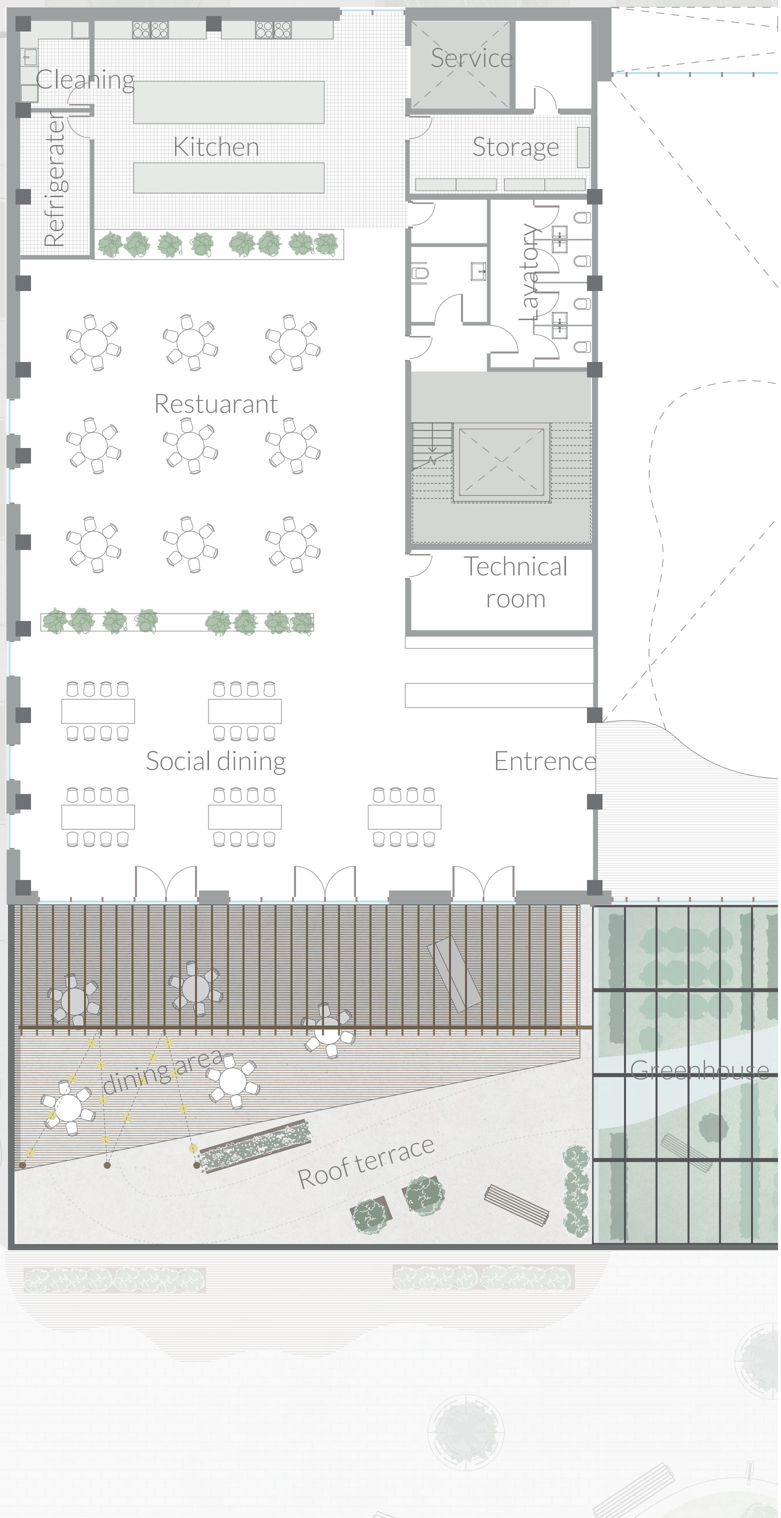
Illu. 14: Hydroponic Exhibition

Third Floor

On the third floor of the cultivation center visitors have reached the end of the food system, the table. Through the progression of moving up in the building visitors will experience the whole system from seed to growth to table.

Here the restaurant is situated, which contributes as a canteen for the employees, a space for weekly social dining and for renting out for events for the locals in the area. Organized towards the north, the more practical functions such as kitchen, storage etc. are placed together with the administration of the center.

Furthermore, a cooking workshop where visitors can learn how to use and prepare the fresh produce of the center is placed in the southeastern corner. In connection to the room, is an outdoor dining area which can be used in the warmer seasons for social dining. Taking up the whole of the southern façade is the roof top garden. Which is organized into different zones, with a greenhouse production where fresh vegetables are grown, as well as seating areas for leisure and an outdoor bar for summer evening events.



Illu. 15: Floor level 3 Grobunden 1:250

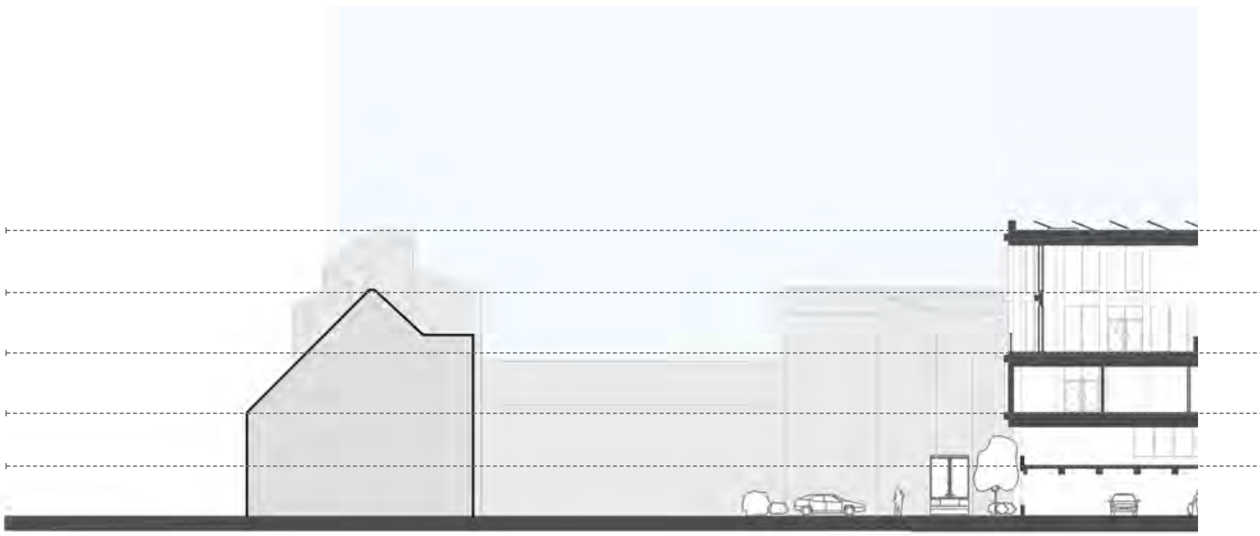
Roof Top Garden

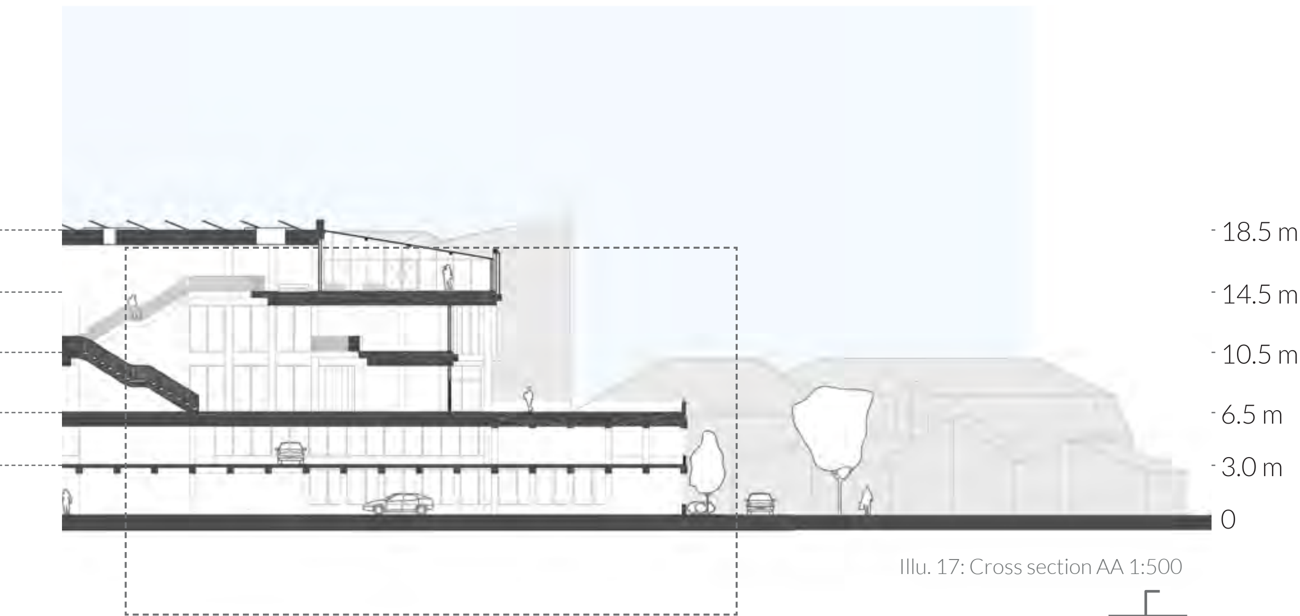
On the top floor of the cultivation center, the beautiful green rooftop garden and greenhouse are placed. It provides a retracted open space for visitors to come and enjoy the views and the activities of the different functions within and outside the center.

The cooking class's outdoor area and the small seating area provide plentiful seating for common use and social gatherings or for more retracted conversations. With views of the urban farms and the greenhouse, visitors can come and be a part of the interaction of harvesting and planting. The diverse pavement enhances a zone change where the flow changes its speed.

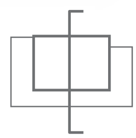
Illu. 16: Roof top garden

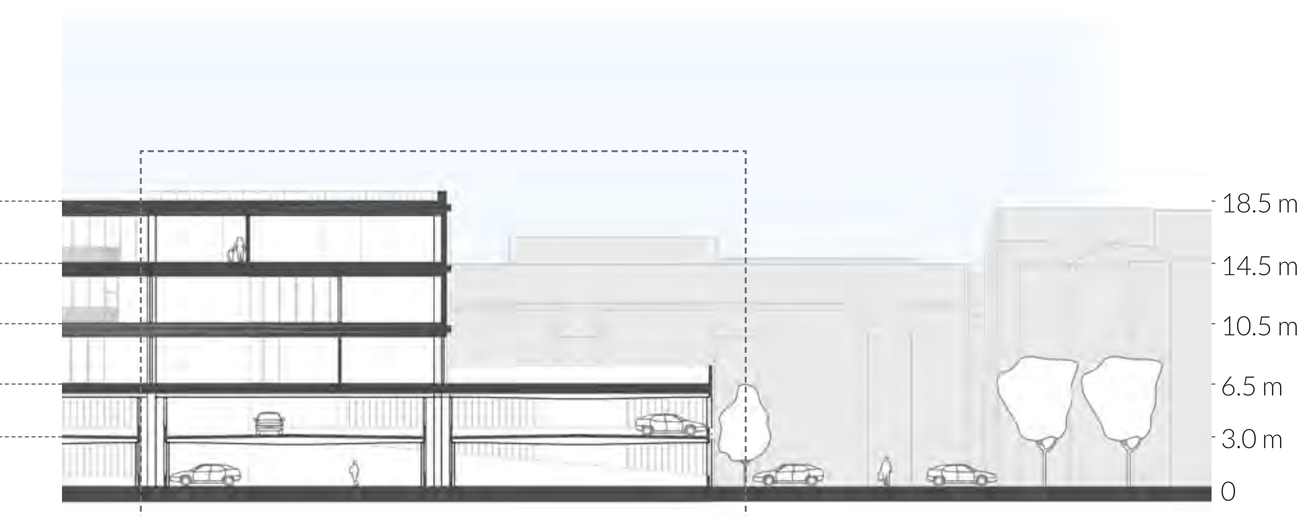
Building Sections



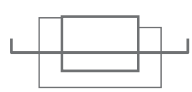


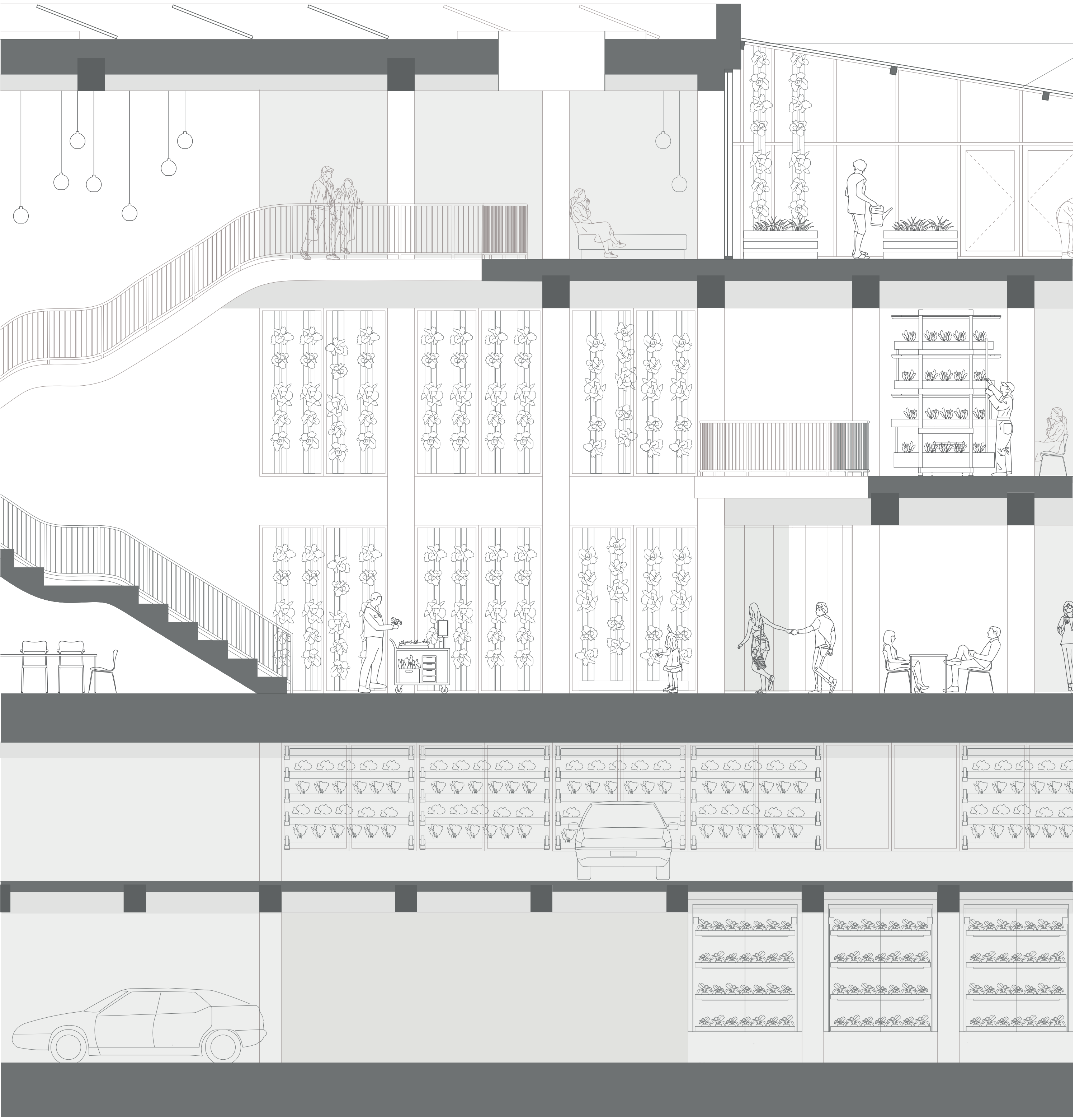
Illu. 17: Cross section AA 1:500





Illu. 18: Longitudinal section BB 1:500



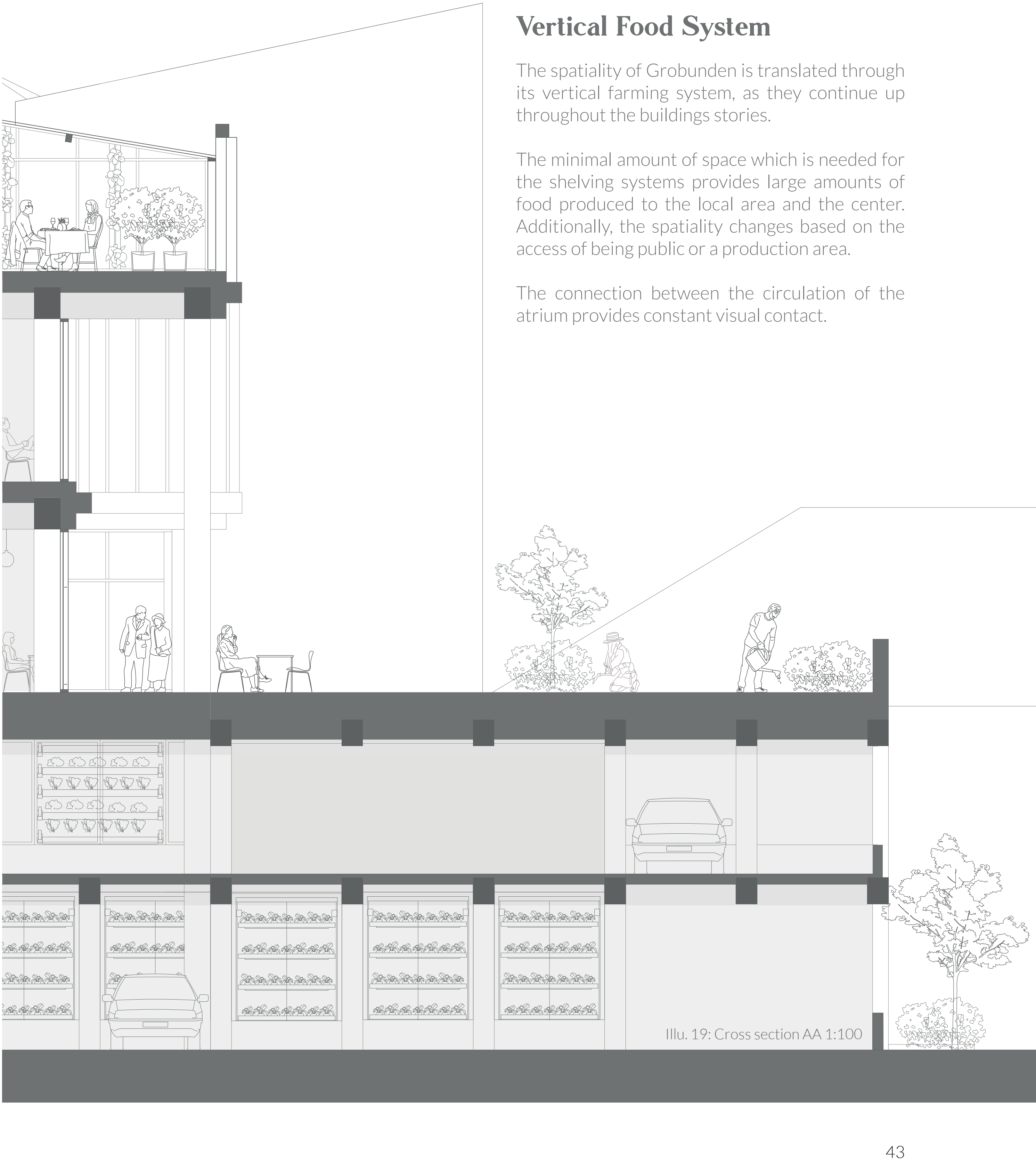


Vertical Food System

The spatiality of Grobunden is translated through its vertical farming system, as they continue up throughout the buildings stories.

The minimal amount of space which is needed for the shelving systems provides large amounts of food produced to the local area and the center. Additionally, the spatiality changes based on the access of being public or a production area.

The connection between the circulation of the atrium provides constant visual contact.



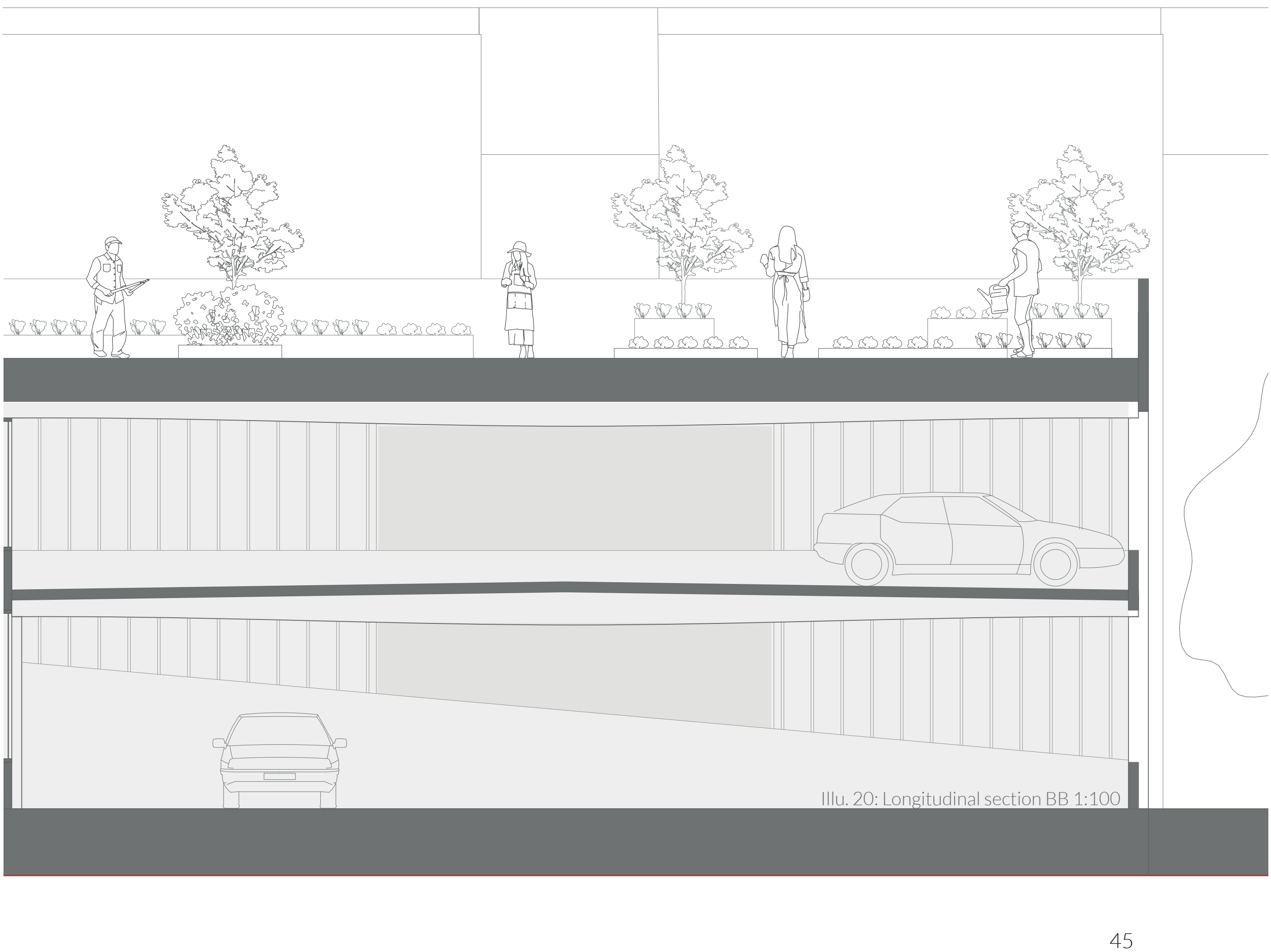
Illu. 19: Cross section AA 1:100

Food Literacy

The mixture of food production and food-based workshops has been organized carefully to provide visual connectivity into the vertical farms to enhance the literacy of the visitors and acknowledge one of the center's main functions.

The placement of the workshops is in relation to the production, such as having the mushroom workshop near the mushroom production etc.

The hybridization of parking space and building is clearly expressed in the section where the vertical farms are intertwined into the reused light shaft of the existing parking house.

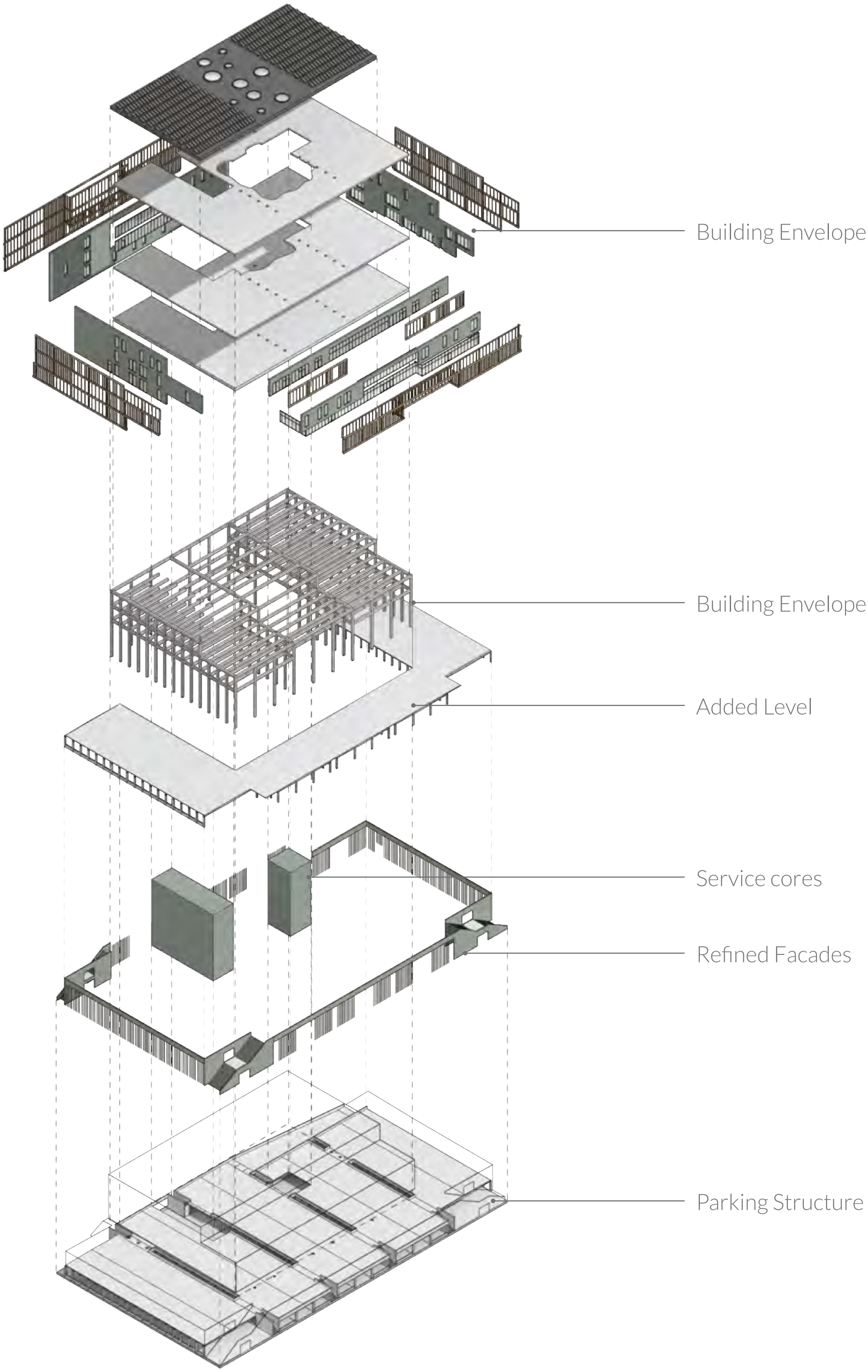


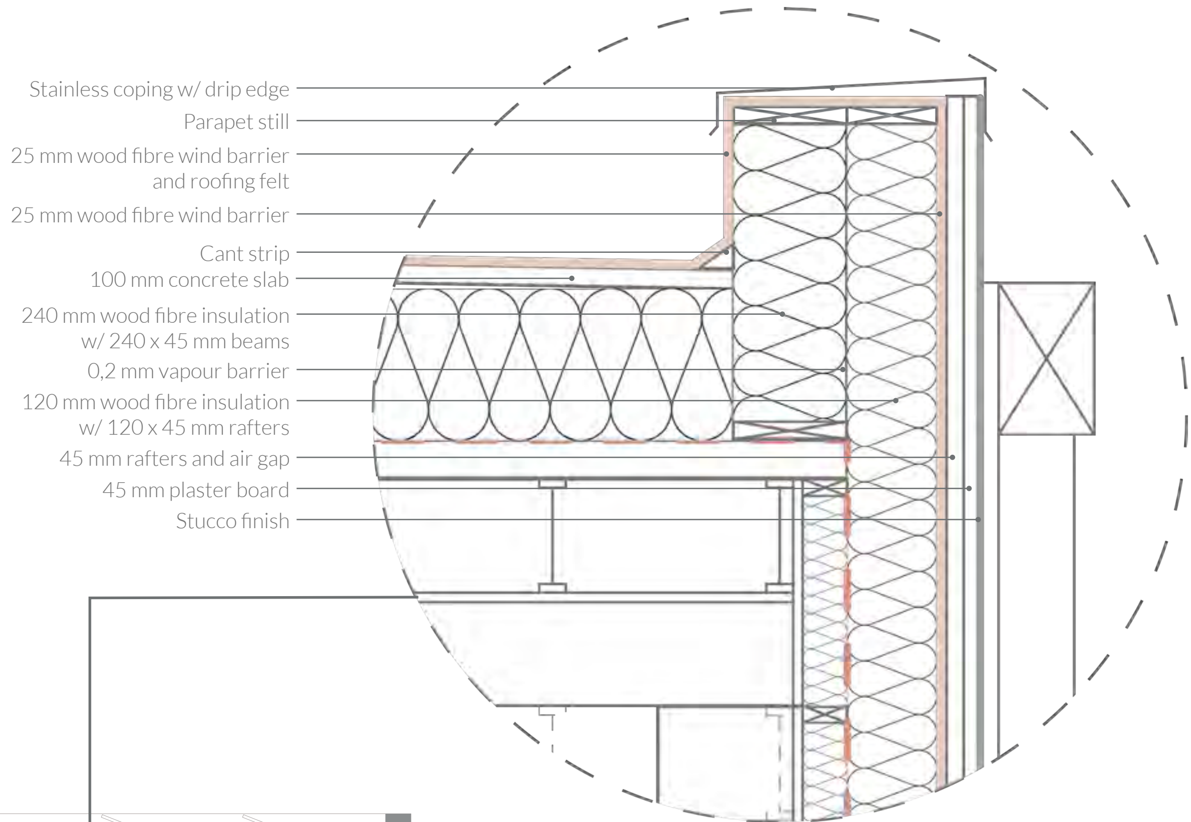
Illu. 20: Longitudinal section BB 1:100

Structural System

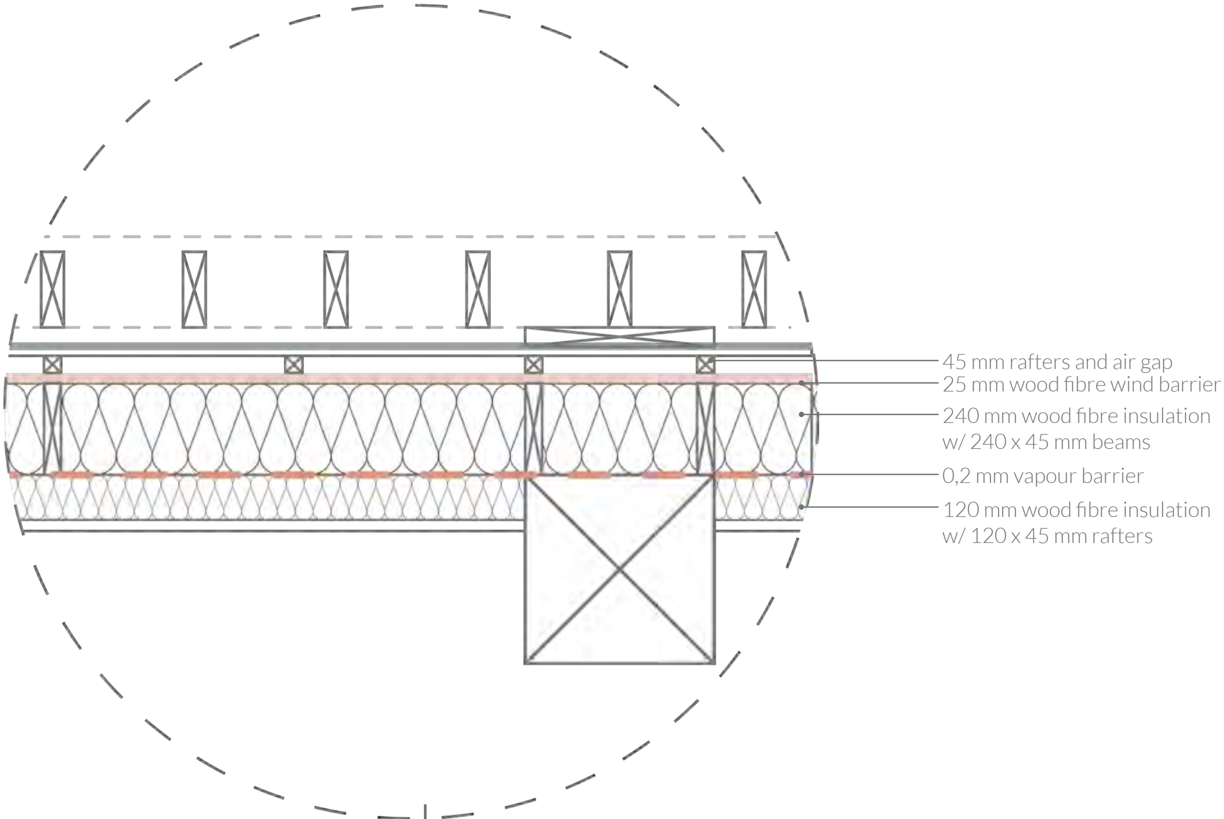
The existing parking structure is built from prefabricated concrete elements in a modular frame system, allowing simple changes by removing some of the frames and decks. The corners of the structure have therefore been replaced with staircases to give pedestrians access to the urban space on top of the parking levels. Furthermore, the stabilizing cores interfere through the parking levels and up through the building.

The load bearing structure of the cultivation center is of same principle as the existing parking structure. The span of the new frames is defined by the shafts in the parking structure, as the columns penetrate through these to retain as many of the existing parking spaces and minimizes its interference with the existing structure. Furthermore, the large spans allow for open spaces inside the building.

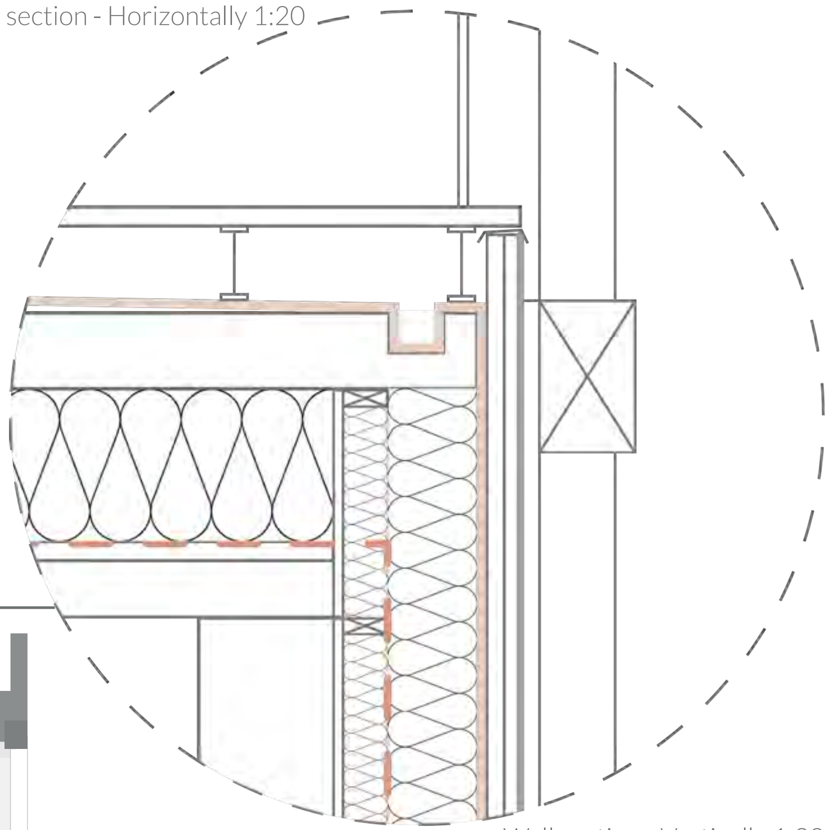

Building Envelope
Building Envelope
Added Level
Service cores
Refined Facades
Parking Structure

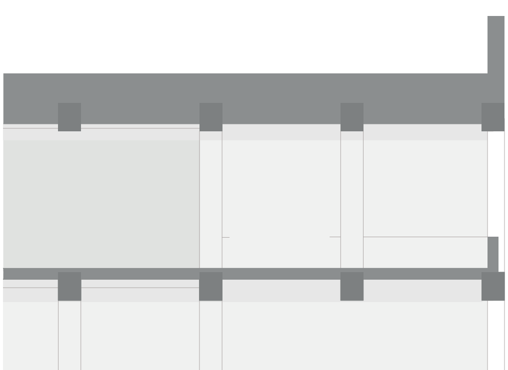


Roof section- Horizontally 1:20

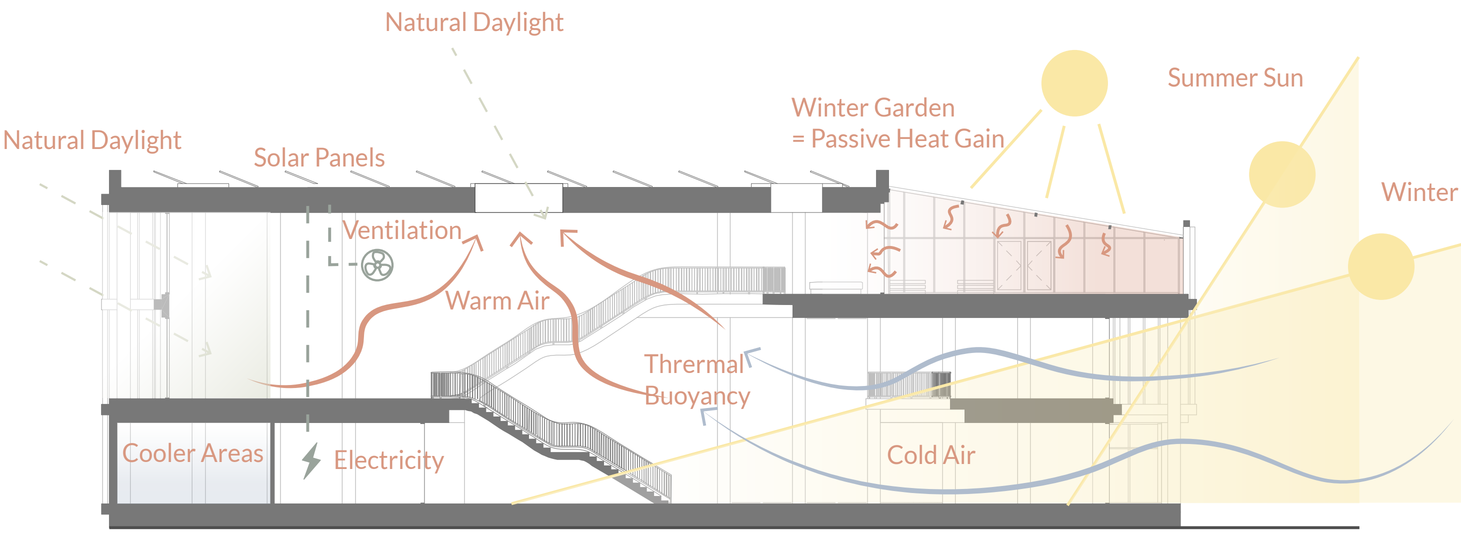


Wall section - Horizontally 1:20





Wall section - Vertically 1:20

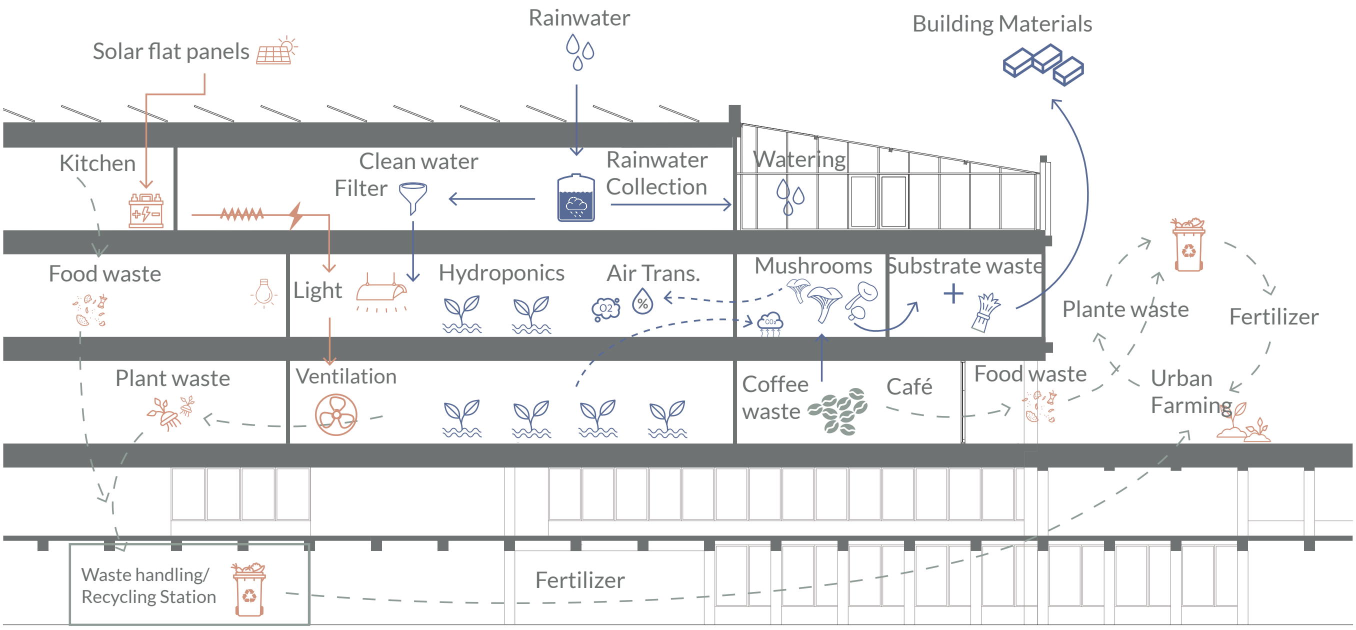


Passive and Actives Approaches

Grobunden has been developed through the interplay of passive design principles together with renewable energy systems to accommodate the buildings residual needs. As the building's program consists of innovative cultivation methods, the building acquires energy to run.

Therefore, passive design features are integrated to utilize natural resources, such as sun and wind to obtain a comfortable indoor climate and efficient building. The compact form of Grobunden minimizes the envelope with appropriate thermal mass and carbon friendly insulation enhances the indoor comfort and reduces thermal bridges.

The orientation takes advantage of the sun by using the advances of heating in the winter, as the retracted southern façade together with the slats acts as a passive means of solar shading from the high summer sun. The fenestrations of the building are strategically placed to utilize for natural ventilation of cross ventilation and thermal buoyancy resulting in a reduced cooling requirement during the warmer months.



The Artificial Ecosystem

The Artificial ecosystem of Grobunden contributes as a technical engine for the building, where outputs from one production becomes inputs to another and therefore becomes a smart solution of an innovative food system.

Through the use of renewable solar flat panels, energy is provided for artificial lights and mechanical ventilation which is used to ensure healthy crops. In addition, a rainwater collector gathers the water which then is used for both filter and watering for the plants and the hydroponic systems. The mushroom farm generates CO2 which can benefit the hydroponic farms, while the substrate and waste from the mushrooms can be utilized for the innovative biobased material made from mycelium.

This symbiotic cycle also reduces food waste through its composting hub in the parking area, which then is used as fertilizer for the plants.


D
E

Writing and Designed by

Karoline Marie Petersen

Kasper Brøndum Kristoffersen

Pernille Løkke

Illustration List

Illu 1: Pie charts with CC- Photos

https://www.google.com/search?q=biodiversity&tbm=isch&hl=da&tbs=il:cl&sa=X&ved=0CAAQ1vwEahcKEwiYibXtpu_-AhUAAAAAHQAAAAAQAw&biw=941&bih=838#imgrc=tNtilAaKiwNaxM [Acessed: 11.05.23]

https://www.google.com/search?q=deforestation&tbm=isch&tbs=il:cl&hl=da&sa=X&ved=0CAAQ1vwEahgKEwj438fMpu_-AhUAAAAAHQAAAAAQhgE&biw=941&bih=838#imgrc=1Br85CGo8q36-M [Acessed: 11.05.23]

https://www.google.com/search?q=containers&tbm=isch&hl=da&tbs=il:cl&sa=X&ved=0CAAQ1vwEahcKEwjw_PyUp-_-AhUAAAAAHQAAAAAQAw&biw=941&bih=838#imgrc=putI9ZkX92iBYM [Acessed: 11.05.23]

https://www.google.com/search?q=fields&tbm=isch&hl=da&tbs=il:cl&sa=X&ved=0CAAQ1vwEahcKEwig1OOqqO_-AhUAAAAAHQAAAAAQAw&biw=941&bih=838#imgrc=RlRLXHl-gdf0oM [Acessed: 11.05.23]

Illu 2-21: own illustration

Illu. 21: Evening render of Grobunden

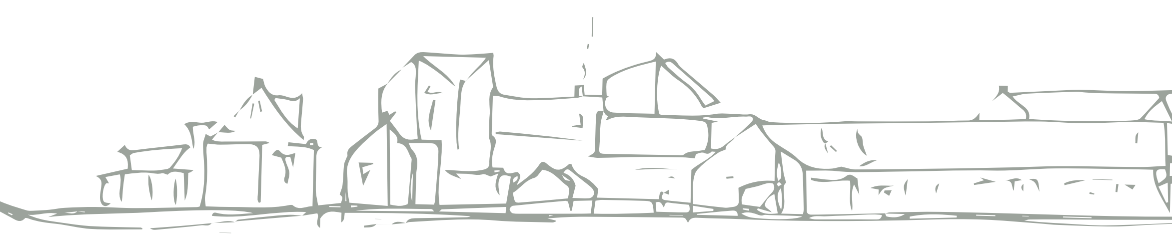
PART ONE

GROBUNDEN

AN URBAN CULTIVATION CENTER

Karoline Petersen
Kasper Brøndum Kristoffersen
Pernille Løkke

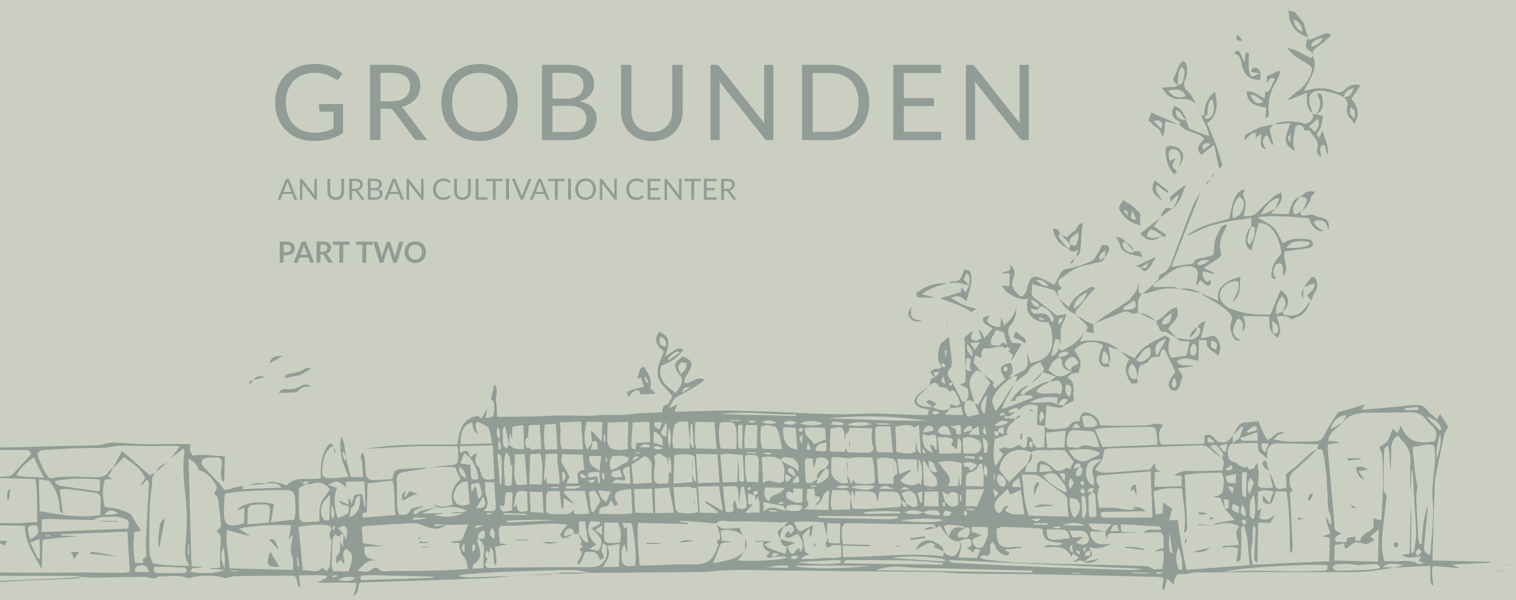
Aalborg University
Sustainable Architecture and Tectonics
MSc04 – Group 22



GROBUNDEN

AN URBAN CULTIVATION CENTER

PART TWO



GROBUNDEN

An Urban Cultivation Center in Aalborg

Project title:	Grobunden
Semester:	MSc04 – Architectural Master Thesis
Group:	22
Main supervisor:	Tenna Doktor Olsen Tvedebrink
Co- Supervisor:	Endrit Hoxha
Project period:	01.02.2023 – 26.05.2023
Institution:	Aalborg University
Number of Copies:	6
Number of Pages:	163
Appendix:	p. 140 -163
Authors:	Karoline Marie Petersen Kasper Brøndum Kristoffersen Pernille Løkke

Illu. 2: Pea sprouts - section

Abstract

The following master thesis represents a proposal towards a future development of a hybridization of modern agriculture and urban cityscapes.

The thesis presents the potential of utilizing and transforming an urban monofunctional parking structure into a multifunctional cultivation center which regenerates the space into an urban catalyst in the city of Aalborg.

It explores and investigates how we can integrate sustainable and innovative cultivation techniques to serve the practical purpose of providing food, while encouraging to rediscover the infrastructure of modern food systems through food literacy related programs.

Reading Guide

The following report contributes as PART TWO of two parts, where this part contains the theoretical framework, site analysis with relating studies and an in-depth design development. The other part presents the final design proposal and contains presentation materials such as plans, sections, visual renders.

01

02

03 ANALYTIC FRAMEWORK 42.

04 DESIGN PROCESS 84.


01

INTRODUCTION

The upcoming chapter constitutes the methodological foundation of the thesis. The chapter includes a description of the motivation which creates the framework of the thesis. The interplay of two different design strategies will be presented as the catalyst for the following development of designing the project. Lastly, methodologies and tools which have helped in the process of designing and analyzing will be explained.

Illu. 3: Microgreen maze of pea sprouts

Motivation and Introduction

Problem

Due to a continuously growing population and an increasing rate of urbanization our natural resources are under pressure as our untouched land is being utilized for agricultural purposes to feed us (Ritchie, 2018). These complex challenges demand a change in how we develop our cities in the future.

The built environment is of fault for the scarce resources today, as we have created an unhealthy and generic building tradition, where materials and the characteristics of the buildings are copy pasted, causing a lack in the experience, the atmosphere, and the wellbeing of living in these.

Furthermore, cities like Aalborg are already relatively dense but there are still voids or wasted spaces, full of potential which need to be re-purposed and designed and make them re-inhabited to be used.

Opportunity

The thesis will investigate the opportunity to address these issues through a hybridization of the built environment and new approaches relating to cultivational design. By integrating the dynamics of our ecosystems into the cityscapes we can change our traditional ways of production to consumption and create an experience for people to see, try, and taste the dynamics of our food system of growing, harvesting, buying, preparing, and eating. It is the physical interventions which alter metaphysical perception.

In addition, there is a big climate friendly potential in utilizing existing spaces in the city. An alteration or a re-purpose of the built environment can become part of the future for the new place, resulting in an elongated lifespan. Architecture has the potential of being a catalyst in the urban setting, through its aesthetics and programming as it can influence and promote interactions and life inside and around it.

Setting

The 11-year-old two story parking lot in Sauers Plads, central Aalborg, is currently only meant for parking (Termansen, 2012). It takes up a big plot of a central area of the city that is surrounded by apartment blocks, a local police station, fire station, health center, stores, and a park. The raw concrete construction stands as a "wasted space" meaning that it has the potential to be much more than just a parking lot and serve more purpose for the local area as well as to the city of Aalborg.

Therefore, this setting will constitute as a platform to investigate how basic daily architecture in an urban space can promote a change both socially and physically by adding meaningful architecture that can promote knowledge and experiences to the daily, weekly, occasional, and seasonal visitors of Aalborg.

Intention

This thesis explores and investigates how architecture can address the global food crisis and issues related to traditional agriculture through the potential of using modern cultivating methods and existing urban wasted spaces, here the aim is to start addressing the problem by creating an urban cultivation center in the city of Aalborg.

To enhance the knowledge surrounding food, the building will act as a center with functions related to and focusing on sustainable agriculture, nutrition and health, food, and social equity and sustainability.

Furthermore, through an environmentally sustainable approach, the thesis will explore how the use of materials can enhance the atmospheres of spaces, like using waste from the cultivation methods as building materials and enhance expressive qualities and at the same time serve the practical purpose or minimizing the carbon footprint of the building.

How can urban cultivation methods be integrated in existing cityscapes, to support food security for the rising population in the cities, and act as a new catalyst for a social- and food literate typology.

- Problem Statement

Strategy for Design Development

The Integrated Design Process (IDP) and the Double Diamond Design Process (DDDP) are combined to form the design strategy for the project. The DDDP is a general design strategy focusing on when to gather information and ideas to expand and create a knowledge base, while IDP is a strategy more specific for architectural projects. This method provides the specific phases and guidelines towards the tools needed to solve the different phases in the design process.

The Integrated Design Process

The Integrated Design Process is divided into five phases: problem, analysis, sketching, synthesis, and presentation. Every time new knowledge is gained, the phases are repeated, and the design is revised based on this new knowledge. Through this, a creative interactive process is created while an understanding of the project from the initial idea to the final product or presentation is gained. Furthermore, the process can support a holistic architectural design through a direct relation between technics, aesthetics, and functions (Knudstrup, 2004).

Double Diamond Design Process

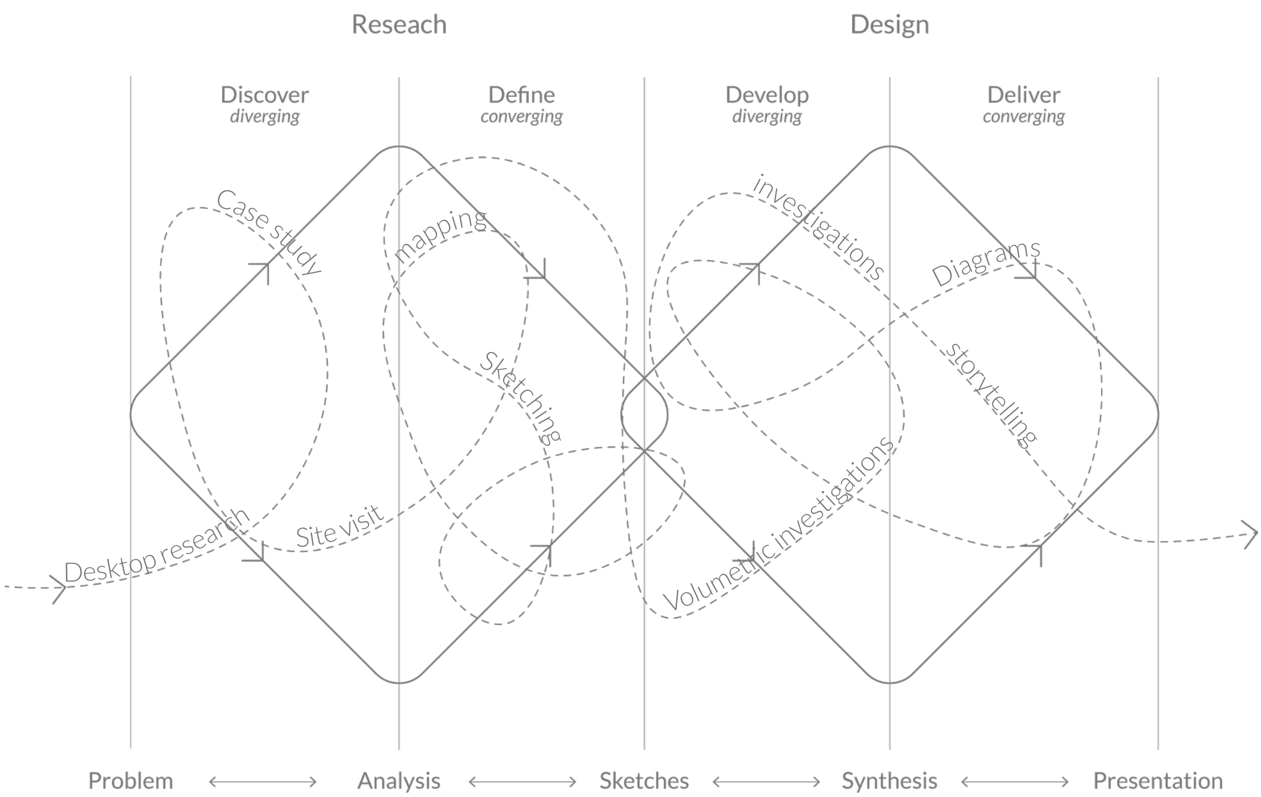
The British Design Counsil created in 2005 the Double Diamond Design Process, which maps the divergent and convergent stages of the design process. It is a dynamic process working with four phases; discover, define, develop, and deliver. The first half is about designing the "right" thing through research, while the second half is about designing the thing "right" (The British Design Counsil, 2005).

Discover
The first phase is characterized by divergent thinking and investigating a wide range of ideas and opportunities. It is all about keeping a broad perspective. The phase often starts with an idea or inspiration deriving from a discovery process. In order to reach the next phases, it is important to understand the problem and the extent of the idea.

Define
The second phase is a convergent approach to specify the problem definition. Ideas, knowledge, and results from the first phase are analysed and synthesized into a written guideline or brief for the following phases in the project.

Develop
After the definition of the problem is specified, ideas for the solution and the final product are investigated through different design methods. Again, the horizon is expanded with investigations of different concepts and design ideas, while focusing on the realization of the project.

Deliver
In the last phase the final concept, final testing, and the delivery of the final project are in focus. The specific problem from the discovery phase is solved and the project reaches its completion. Here, it is about the delivery and communication of the project and knowledge gained.



Illu. 4: Strategy diagram, IDP and Double Diamond Design Process

Methodologies

For accumulation of knowledge these methodologies and tools have been used.

Desktop research
Throughout the thesis time period, desktop researching has been used in terms of finding information and knowledge of the stipulated problem. Primarily in the early stages of the project development gathered information and knowledge, have then been evaluated with the ability of being critical towards where the acquired data has been collected.

Tools used: books, internet, articles, data sites.

Case study
Case reference contributes as inspirations and are useful to provide evidence based and practical knowledge of certain designs as well as they allow for picking out exact design and focal points to acquire specific information of elements of the design or construction, as example using the size of an roof top garden from Østergro in the development of the thesis future design.

Tool used: literature, magazines of architecture, databases like Deezen or Arch daily or straight from the architectural firms' databases.

Sketching
Contributes to drawings which can be used to express creativity, design proposals or quick diagrams to communicate ideas

Tools used: analogues sketching and digital sketching

Ethnographic mapping:
Contributes to acknowledging the site surrounding context both physically but also phenomenologically. Provides information about height, scale, size terrain, vegetation and use ect. Alongside arrival and infrastructure. The more atmospheric mapping of the site contributes to capture an essence of the place which then is translated into finding out how it either can be enhanced or changed through the architecture or urban planning.

Tool used: collages, adobe illustrator, Skråfoto, Google maps

Study trip
Throughout the thesis time period, site visits have enhanced the understanding of the use and the life around the site through different weather situations and seasons. These visits have been documented through pictures, notes, and measurements.

Tool used: camera, notebooks, measuring instruments.

Volumetric investigations
In the early design development, different studies of volume and massing have been conducted to explore their different potentials.

Tools used: rhino 3D, sketchUp, models from foam and cardboard.

Technical investigations:
To examine the design proposals different elements such as fenestrations, indoor climate in regard to daylight and heat gain.

Tools used: Life cycle assessment LCA-byg , 24-hour temperature calculation, mean month calculation, Grasshopper, Rhino

Inspiration boards
Creating early inspiration boards contributes to getting a collected visual picture of what the vision of the design is.

Tools used: boards, pictures from different platforms like Pinterest, scissors, tape

Experiments
To gather knowledge and hands on experience of how the cultivation methods function and how to create materials for interior purposes, different experiments have been made throughout the process.

Tools used: water, trays, fan, hemp sheets, soil, a variety of seeds, mycelium spores, substrates like hay and hemp, different containers, coffee grounds.

Illustrations:
Throughout the report different illustrations have been created to enhance the understanding of the written. Their purpose consists of communicating the design when this can't be done though text.

Tools used: Illustrator, hand drawings, collages.

Infographics:
To support information and data, info graphics are created with the purpose of creating a visual understanding of the complexity of the topics.

Tool used: adobe illustrator, Photoshop, Photo clippings

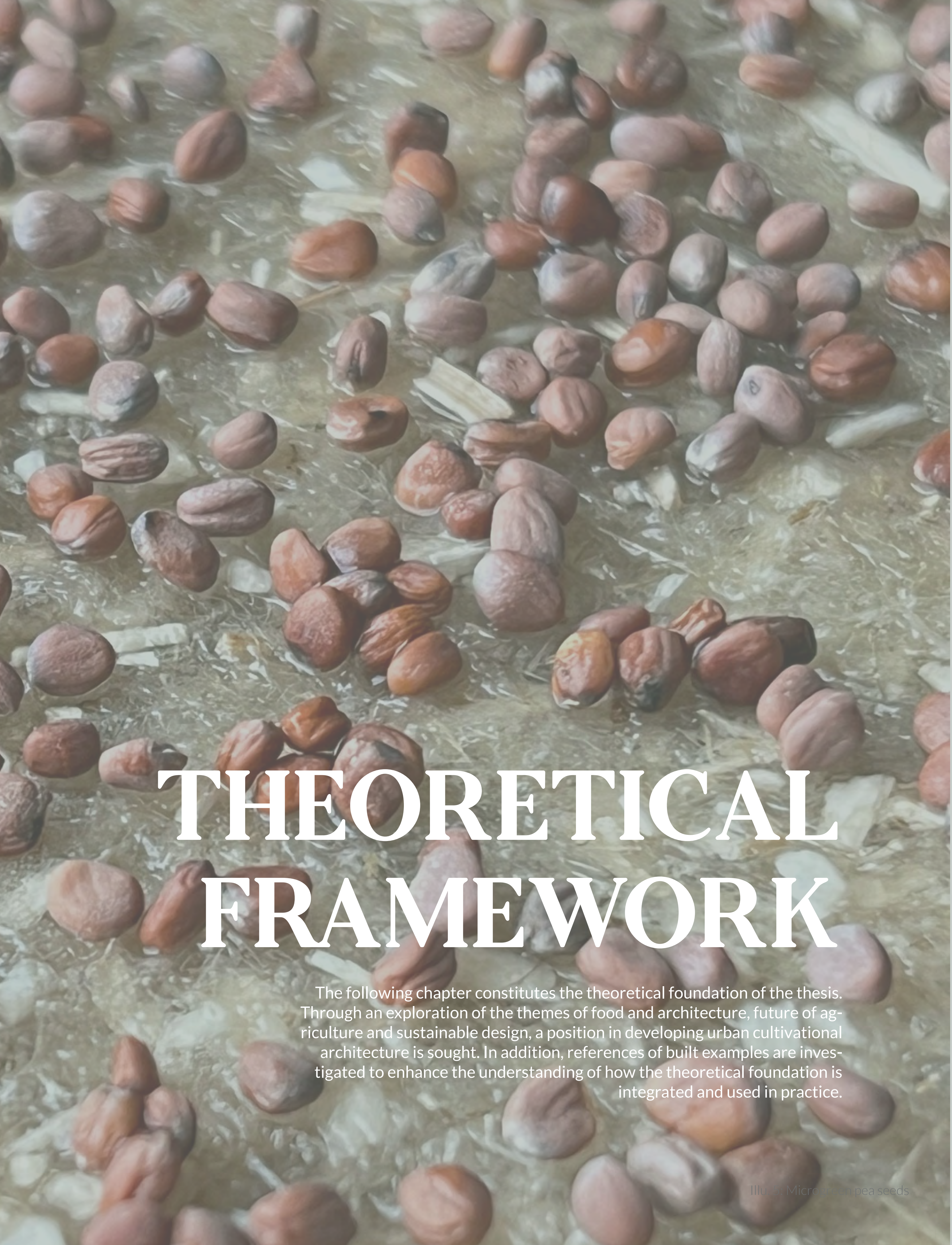
Renderings:
In the last phase of the design process, Visualizations have been used to create a visual representation of defined spaces of the built typology, these can provide atmospheric understanding of a space and the use.

Tool used: Sketch- up, Rhino 3D, Enscape, Photoshop

Report layout
The report consists of story telling the entire process of the development, and documenting all aspects of the design and its many process phases which include theoretic, analysis and finally the presentation of the development. The purpose of the report is to showcase for the reader the challenges and the evolution of the design.

Tool used: Adobe InDesign

02



THEORETICAL FRAMEWORK

The following chapter constitutes the theoretical foundation of the thesis. Through an exploration of the themes of food and architecture, future of agriculture and sustainable design, a position in developing urban cultivational architecture is sought. In addition, references of built examples are investigated to enhance the understanding of how the theoretical foundation is integrated and used in practice.

Illu. 5: Microgreen pea seeds

The Future of Agriculture

The Increasing Food Crisis

In the last 60 years, the world population has increased from three billion in 1960 to nearly eight billion in 2021 (Roser, Ritchie and Ortiz-Ospina, 2020). While the population is growing more people are moving to urban areas. Earlier the rural population exceeded the urban population, but in 2007 these equalized. Since 2007, the urban population has rapidly increased, creating a difference of one billion in 2020, with 4.4 billion people in urban areas and 3.4 people in rural areas (Ritchie, 2018). Currently, up to 70 percent of the world emission of carbon dioxide is accounted for by the cities. By 2050, the world population is expected to grow to almost ten billion people where 80 percent will be living in urban areas, presenting a long list of issues needing to be solved (Kalantari et al., 2018).

While the population is increasing, the world is experiencing a food crisis with a drop in agricultural food production of 20-40 percent, while the human carbon footprint and effect on the air quality is only increasing. With the increase in population, food production follows (Kalantari et al., 2018). Half of the world´s habitable land is used for agriculture, depriving the soil for nutrients, and having detrimental effects on the herbal ecosystem and biodiversity (Ritchie and Roser, 2019). Concurrently, there is a rise of health and environmentally conscious consumers, increasing the demand for clean and healthy food produced with a low impact on the environment (Van Gerrewey, Boon and Geelen, 2022).

Illu. 6: Statistics for the food crisis

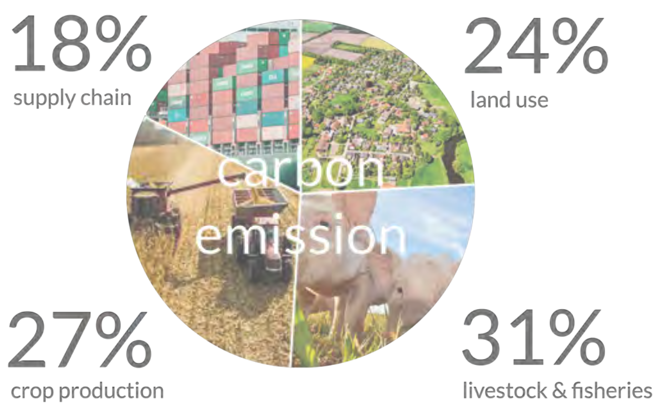
Traditional Agriculture

One of the major challenges in the twenty-first century is food production concerning global environmental problems such as increasing population, climate change, and natural resource degradation including biodiversity loss. Generally, food production accounts for one quarter of the global greenhouse gas emissions. Crop production is responsible for one quarter of the food emissions (includes human consumption and animal feed) while the supply chains are responsible for 18 percent (includes food processing, packaging, transport, distribution, and retail) (Ritchie and Roser, 2022)

Today, one of the key problems with the current farming methods is the amount of land needed. Converting natural land into farmland has a detrimental effect on the biodiversity, herbal ecosystem, and nature. In fact, half of the world´s habitable land (ice- and desert-free land) is used for agriculture and in Denmark it is as high as 66% (Ritchie and Roser, 2022).

This distribution of the land areas influences wildlife and natural land. Since 1970, thousands of wildlife populations have suffered a large decline in the Living Planet Index (LPI), which has dropped to almost one-third (Ritchie, Spooner and Roser, 2022). Furthermore, open-field agriculture has a run-off and leaching of excessively used phosphorus and nitrogen, which can cause the eutrophication of equative and terrestrial ecosystems. This run-off is one of the major sources of contamination in the world today.

Another major problem with food production is the amount of water used. In Europe, approximately 3000 liters/person/day of water is regularly used for food production (Kalantari et al., 2018). Specific for agriculture, 70 percent of global freshwater withdrawals are used, while 78 percent of the global ocean and freshwater eutrophication is caused by agriculture (Ritchie and Roser, 2022).



Illu. 7: Statistics for traditional agriculture

Modern Agriculture

Definition of vertical farming

"VERTICAL FARMING" AS A VERB CAN BE DEFINED AS THE MULTI-LAYERED PRODUCTION OF PLANTS TO INCREASE YEILD PER SURFACE AREA.

Vertical farming has two definitions. The activity "vertical farming", which can be defined as the multi-layered production of plants to increase yield per surface area. As the noun "vertical farm" it can be defined as a highly controlled indoor plant production system. Vertical farming as a term was first coined in 1915 by the ecologist Gilbert Ellis Bailey, but he gave the term an entirely different meaning. His definition suggested farming deeper into the soil by using explosives to reach the depths of roof growth. Generally, urban gardening is not a new phenomenon. During the second world war, food shortages employed gardens on rooftops, balconies, and public parks to increase food production. Waste spaces around the cities were repurposed and exploited for urban farming (Doron, 2005).

Definition of a vertical farm

"VERTICAL FARM" AS A NOUN CAN BE DEFINED AS A HIGHLY CONTROLLED INDOOR PLANT PRODUCION SYSTEM.

In C.J. Lim´s book Smartcities and Ecowarriors, he addresses issues concerning world´s growing population, food crisis, and future possible solutions. During the Paris Climate Conference (COP21) in 2015, an acknowledgement of the link between hunger and climate change was reached. A focus was made on fostering climate resilience and low greenhouse gas emissions development in a manner that does not threaten food production. With the inevitable exponential growth of the urban environments, future cities are to incorporate mechanisms for food production. One problem, with urban residents´ food is the easy availability and the missing concern about the accessibility or affordability. The food is simply just "there" (Lim and Liu, 2019a).

> “
> *The smart city's principal concern is not to overcome nature, nor to strive to preserve the natural environment in its original state, but to harmoniously integrate built form with nature. It is neither a fixed place nor a singular approach but rather a manifesto to produce resilient spaces relevant for the 21 centuries in the face of climate change.* “
>
> *– C.J. Lim (Lim and Liu, 2019)*

Today, there is a rapid expansion and interest in vertical farming. Many initiatives for vertical farming are driven by two main factors. Firstly, the increased consumer demand for sustainably grown fresh, healthy, and local produce. Secondly, the development of affordable light-emitting diode (LED) lighting technologies (van Gerrewey, Boon and Geelen, 2022). Vertical farming brings several opportunities and challenges concerning climate changes, food quality and quantity, and social aspects.

The environmental benefits for moving agriculture to urban areas in the form of vertical farming are the conservation of biodiversity, reduction of wastage and loss, contraction of the energy used for producing and providing food for the public. Food production using vertical farming can be highly controlled and optimized compared to traditional agriculture. With an optimized climate, it is possible to grow crops at all times compared to conventional agriculture where only one crop can grow at a time – monoculture. With full-year stability, vertical farming can produce almost 23 times more lettuce on the same amount of space as in conventional farms. Generally, each closed-space acre is equivalent to 4-6 acres of open field depending on the type of crop. Through these advantages, vertical farming can provide more food in the least amount of time (Kalantari et al., 2018)
.

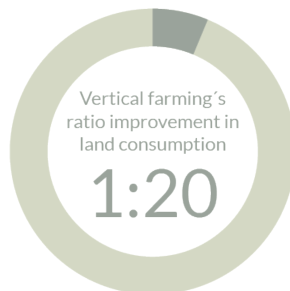
> “
> *In vertical farming, all the ideal conditions required for optimum plant growth can be achieved indoors such as, heating, lighting, water, humidity, amount of nutrients and suitable settings that can all be controlled and managed for a specific crop.* “
>
> *- (Kalantari et al., 2018)*

Opportunities of Vertical Farming

The opportunities for vertical farming are many, but there are still challenges to be addressed in order to reach its full potential. Some of the challenges concern the limited or non-existent exposure to the sun which presents an extra cost to lighting for the plants to grow. Despite the extra cost, lighting extends the season to the full year presenting an opportunity for more crops. The temperature, lighting, humidity, airflow, watering, and other conditions are highly controlled in vertical farming creating an environment where the crops can thrive. An aeroponics or hydroponics together with a closed loop system can manage to save up to 70-80% water compared to conventional farming techniques.

Using a closed loop system can eliminate farming wastewater and the potential hazardous to the environment and human health. Another benefit of vertical farming is land use. Vertical farming has a 1/20 ratio of improvement in land consumption, which means a saving of 95%. The land currently used for farming can be restored to its original natural state and improve the world´s biodiversity. Finally, vertical farming can be located as wanted. If placed close to the consumers, transportation can be cut down significantly. On top of the savings in transportation, it minimizes infestation and spoilage, which is the cause of 30% loss of food today (Kalantari et al., 2018).

Illu. 8: Statistics for loss of food



Illu. 9: Vertical farming ratio in land consumption

Vertical farming can be part of the solution and potentially be beneficial in increasing food production, maintaining high quality and safety, and contributing to sustainable food production in urban areas (Kalantari et al., 2018). Productions have been established around the world showing the opportunities vertical farming brings.

Nordic Harvest in Denmark is a production facility just outside Copenhagen with a 14-story tall hydroponic system, which allows them to sow and harvest every day. Nordic Harvest is situated in the outskirts of Taastrup, still with some transportation to the center of Copenhagen. The intention of this project is to move and integrate larger productions to more urban areas. Their vision is to be part of the solution for food production and the environmental issues food production causes today (Nordic Harvest A/S, 2023).

Illu. 10: Vertical farming princip

Food and Architecture

We live in a time when food is always available. Today we can, with the click of a button, order food to be delivered into the safe space of our own home, without having to do anything else but greet it by the door. As architect and author Carolyn Steel states in her book hungry cities; “Food arrives on our plates as if by magic and we rarely stop to wonder how it got there” (Steel, 2015).

Today we are witnesses to a global food crisis as a result of the rising world population. But many of us are too encapsulated in our everyday life too. Steel argues that food and cities are alike in a way that they are so fundamental to our everyday, which make them easily forgotten and too big to notice.

We have become so cut off from the open country and farming, which is also affecting our eating habits. As we have grown blind to our current food systems, we don't realize that by the time the food finally ends in our kitchen, it has often travelled thousands of miles through airports, harbors, warehouses, and factories. While at the same time being touched by many unseen hands. Furthermore, as an economically aspect we are in a current global inflation, but we are still rich in food as we are provided with so many options of the same product, we just go down on the quality and the taste.

We must face changes and try to re-discover these hidden infrastructures of our food production, because it could make us more present in our surroundings and cities, as well as promote knowlegde about our food. We need to remember that the “relationship between food and cities is endlessly complex, but at one level it is utterly simple, without farmers and farming, cities would not exist” (Steel, 2015). But of course, food is more than just a basic necessity of life, or production, economics or culture.

“

Food in most cultures is the glue that binds families and communities and the restoration of the primal link between town dwellers and their sustenance would constitute an important foundation to an increasingly ungrounded universe. “

– C.J. Lim (Lim and Liu, 2019)

New approaches tend to work if they are accepted both emotionally and rationally, and therefore we need to change our traditional ways from production to consumption and instead see the dynamics of our food system and how we grow, buy, prepare, and eat our food.

We as architects, designers, engineers, and urban planners are almost obligated to investigate new ways of city development and food production and rethink how we can intertwine these, just as C.J.Lim talks about in his book.

In his book Smartcities, Resilient Landscapes + Ecowarriors, Architect and author C.J. Lim questions the possibility of cross programming public buildings and timeshared streets with productive landscape, and this raises the question on how can we design buildings for food literacy?((Lim and Liu, 2019b)

We have examples of these food-based museums and centers, where some provide hands on experience and knowledge of certain types of food. Like wine farms and food museums, these are spread out around the world and may have good qualities in regards of programming and architecture which are created for the purpose of celebrating for example the wine, from fruit to bottle. But from a critical point of view, wine farms and food museums are often either seasonal or placed on the outskirts of cities or in the country, which only makes them visited at a specific time of year and often they become a one-time visit.

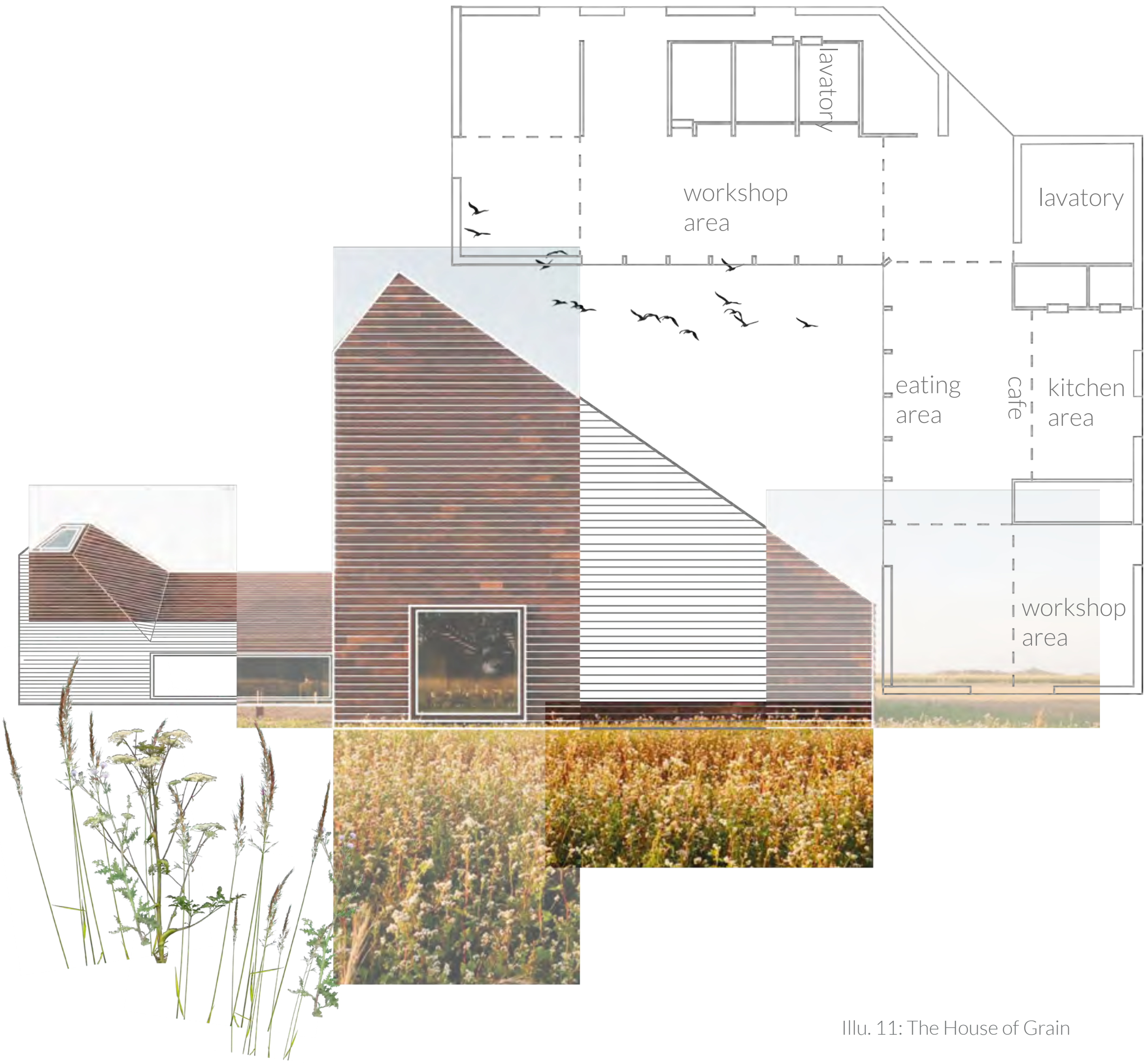
C.J. Lim addresses the possibilities of how a hybridization of agriculture and urban fabric could lead to an association, which is more symbiotic, reducing the carbon footprint and food shortage and additionally providing a significant environmental and social benefit.

What if we could build buildings where people could experience the food from soil to table, in the center of our cities? Where people could easily go and see the production almost as an exhibition, and where it would be possible to touch, feel, smell, and taste the freshness of the food. While in the meantime learn how to grow the crops at home and prepare them for a meal or just go for the experience of having a meal at the restaurant.

This thesis aims to design a building which can act as a food literacy machine, where each space of the building celebrates the process of cultivation and turning the crops into a meal, a place which can lift the spirit of the visitors as well as serving practical needs.

"We are urban city dwellers need to reengage with the roots of our sustenance, the implementation of urban agriculture, the cultivation, processing and distribution of food in within the city. Would have the two fold effect of making these processes transparent and offering a means for the reestablishment of food and its production as a social relation ship."

- Carolyn Steel



Illu. 11: The House of Grain

CASE STUDY

The House of Grain

Architect:	Reuilf Ramstad
Location:	Hjørring, Denmark
Year:	2020

House of Grain was designed by architect Reiulf Ramstad. This brick cladded building is situated in the rural landscapes of Hjørring, Denmark in between the fields. The house is an inspiration center surrounding the dissemination of the region's food and farming culture (Ramstad, 2020) . Through its activities and programs, it offers the visitors and locals interactive learning which is centered around the grain.

The simple organization and flexible plan allow for a variety of different activities such as cooking classes and lectures. It consists of a café, a bakery which offers baking workshops and courses. An Exploratorium and exhibition which displays history and knowledge concerning grain.

The natural setting offers the visitors the chance to take part in nature and enjoy the view of fields. The form is derived from the local folk culture and agricultural heritage. The center of the building is defined by two brick clad light wells, which are supposed to reinterpret a baker's kilns. The architecture opens towards the west and frames the view of wheat fields.

The case contributes as a great tool for providing evidence-based information about how to program for the future development of the building and its users, by expanding the functions of the building could provide an extended use and activity of the building making it a daily food focused machine where people can buy, or actively join cooking classes or learn about growing greens at home.

Environmental and Social Sustainable Design

Designing for Environmental Sustainability

The intention of creating a new typology is to articulate the growing problematics of the raising population, followed by an expanding urbanization causing large untouched nature and forest to be demolished into agricultural land. The design proposal will support the ambition of developing a sustainable architectural design which will emphasize two aspects of sustainability; the environmental and the social discipline, whereof economics is the third.

Environmental sustainability concerns our planet, and it is unavoidable to change the current state of the climate, but it is evident that a change needs to be made to ensure the future state of it.

Currently buildings, bridges, and roads are responsible for 30 % of Denmarks carbon emission. And building materials alone are the cause for 10% of the carbon footprint and just by changing our current building traditions and changing to more sustainable materials, we can reduce buildings carbon emission with 50% by 2030 (Nielsen. H et al., 2019).

Addressing the environmental impact which is caused by the building section the development of the design will accommodate to minimize the carbon impact by considering materials and choose these based on their properties, carbon footprint, patina, and their efficiency of emphasizing the hybridization of food production and food knowledge.

In addition, we are experiencing a drastic climate change where the weather is more extreme, with larger rainfalls, higher sun exposure and rising temperature. These are only some factors which should be considered in the process of building an urban cultivation center. As a result, this thesis will investigate how to integrate and utilize different passive means, such as adapting to the climate through orientation, form and utilizing additional active means to mitigate these changes.

Through the interdisciplinary of engineering and architecture the building will be tested through a material investigation and calculation with the use of the life cycle assessment program LCAbyg to ensure the standards of aesthetics, function and structure are aligned with the properties of utilizing less carbon impacted materials.

As architects and designers of the future we need to refurbish, transform, and re-use existing buildings and urban spaces to minimize the building sectors carbon footprint.

This thesis aspires to transform and refurbish the urban parking house in saures plads, Aalborg.

Our building traditions are becoming uniform and traditional which is exhausting and exterminating our resources

The future cultivation center aspires to ulitize materials with consideration and cautious of our resources.

It is time to change our material resources into more enviormental friendly.

Grobunden will therefore examine different materials to minimize the overall carbon footprint of the building

Illu. 12: Statistics for environmental sustainability

LCA and Biobased Materials

Based on the goal of minimizing the Danish carbon emissions with focus on the building sector, two new requirements were released concerning new buildings climate impact. As per January first, 2023, buildings over a thousand square meters must comply with a threshold value for global warming potential of 12.0 kg CO_2- eq. /m^2/year this includes the buildings energy use and materials. This threshold needs to be documented through a climatic calculation, for instance from a life cycle assessment, where the climatic impact is made based on a period of 50 years. Furthermore, this threshold will be tightened as of 2025, where it will concern all new building developments (Videnscenter for bygningers klimapåvirkninger, 2023).

Life cycle assessment, or in short LCA, is a calculation method which has been incorporated in modern day sustainable design as a means of quantifying a building's environmental performance in relation to its total carbon emission. It calculates the total global warming potential (GWP) of a certain material, element or full building through its different life stages (Videnscenter for bygningers klimapåvirkninger, 2022).

The cycle contains five stages which are divided into 17 modules, but it is only some of these that are valid for the regulations as it else will be too comprehensive of a calculation to do, known as a system delimitation. This thesis will be following the valid stages of the life cycle which have been chosen by the Danish legislation. (illu. 13)

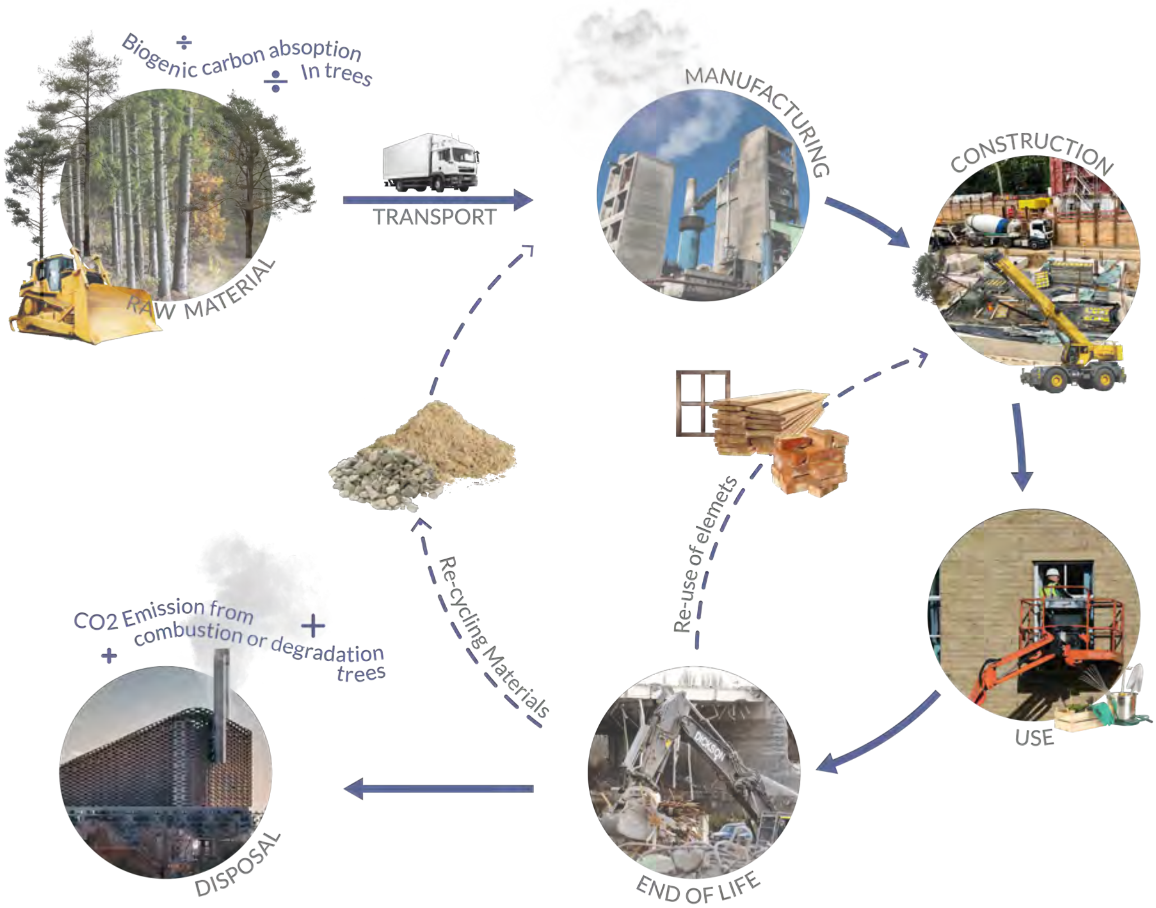
Production Stage (A1-A3): raw material, transport and manufacturing

Usage (B4-B6): replacement, energy consumption for building performance,

End life (C3-C4): preparatory process of waste, disposal

Reuse (D): certain rules apply for this phase, as it should not be calculated into the results, but calculated separately in the documentation.

The thesis will aspire to reach the new building regulations where LCA calculations will be incorporated early in the design phase, in form of acknowledging the building geometry as a parameter to optimizing the buildings climatic performance and through a variation study of materials such as insulation types, cladding, and construction to establish their different properties and potentials in terms of their climatic impact and appearance. Though it is important to state that the decisions are not exclusively based on LCA, but also practicalities such as form and function as well as aesthetic appearance.

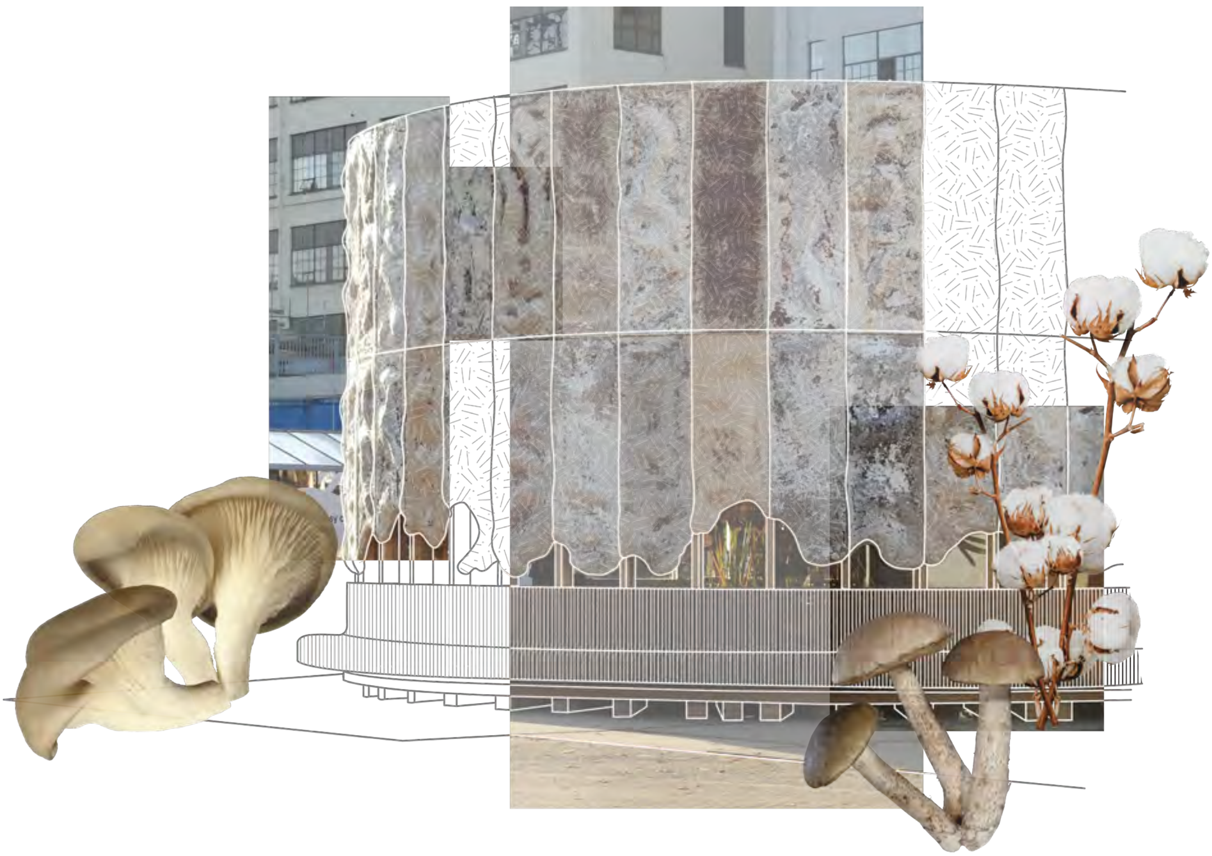


Illu. 13: Life Cycle Assessment diagram

The project utilizes LCA to investigate the potential of minimizing the buildings carbon emission by calculating and evaluating through the program LCAbyg with the focus on utilizing materials which practically fits the typology and use of the building while aesthetically fulfill the overall architectural appearance.

Finally, LCA is not just changing or deciding our building materials alone.

It is a combination of thinking about how certain materials can be minimized, and which materials fit the building form and function the best. It is important to state that the right choice is not always the best choice when it comes to form, function, and construction. Therefore, this thesis will use LCA as a tool implemented in the design process to be part of the decisions made regarding choice of materials.



Illu. 14: The Growing Pavilion

CASE STUDY

The Growing Pavilion

Designed by:	Company New Heroes
Built by:	Friction Factory, Tentech and Buitink technology.
Exhibited:	Dutch Design Week 2019 & Floriade Expo 2022

With the intention of stimulating the conversation surrounding a more sustainable future regarding building materials, the Growing Pavilion was designed as a fully biobased construction. The circular form with its conspicuous appearance is created from five raw materials consisting of wood, mycelium, residual flows from the agricultural sector, bulrush (cattail), and cotton. These have been chosen with the intention of showing the material and the construction as raw as possible.

The first notable thing of the pavilion is the cladding, made of 88 mycelium panels, which has been made from mushroom spores and residual flows from agriculture like hemp or mace that then have been molded and burnt to stop the growing process of the mushrooms resulting in these panels. Furthermore, mycelium has a positive environmental impact in regard to CO_2, as calculations show that producing a ton of mycelium can capture two-ton CO_2 from the atmosphere (van den Berg and Konings, 2019).

The round structure that holds the panels are made from a Kerto construction which consist of aspen wood and pine tree from Finland. Trees also have the capability to capture and store CO_2 from the air and it has a long-life span. The roof of the pavilion is made of wool from the cotton plant, even though it has a weak fiber and had to be integrated with layers of fabric.

Other materials such as eelgrass have been considered, this biobased material has the fantastic characteristic of being naturally fireproof, rot resistant, carbon negative and after some years of drying it is entirely waterproof. Its insulations value is comparable with mineral wool. These include some of the biobased construction materials which the pavilion has utilized to enhance the subject of moving away from our old building methods and looking towards a future where these will become more common to use. With inspiration from these biobased materials this thesis will further investigate the use of mycelium, wood in the future design development of Grobunden.

Designing for Social Sustainability

Social sustainability is the least developed and conceptualized element of the triad of sustainable development. However, it is a fundamental and integral component of sustainability. Generally, social sustainability aims to improve the quality of life, it therefore pays attention to well-being and the most relevant human needs, adaptability, and growth. Social sustainability in cities has been defined as.

"Development (and/or growth) that is compatible with harmonious evolution of civil society, fostering an environment conducive to the compatible cohabitation of culturally and socially diverse groups while at the same time encouraging social integration, with improvements in the quality of life for all segments of the population" (Stren and Polése, 2000).

Green spaces are fundamental to social sustainability in cities since they are accessible to all citizens, enable social interactions, and offer a sense of belonging and participation. The green spaces can have vital influence on communication, education, and health in the neighboring area. They can reduce stress and in general improve health. Therefore, implementing these areas in the cities and urban areas is crucial for social sustainability, but also for environmental sustainability.

This project is intended to form an environment which encourages social interaction, educates the community, and brings a helping hand to vulnerable groups of society. The project focuses on enhancing and creating a connection through its functions and programming and link to the surroundings through its architecture.
It is important to inform the public about food and its production, pointing the focus on the understanding of ´food literacy´.

"Food literacy is described as a concept involving three main domains; food, nutrition and health; agriculture, environment and ecology; and social development and equity" (Bellotti, 2010).

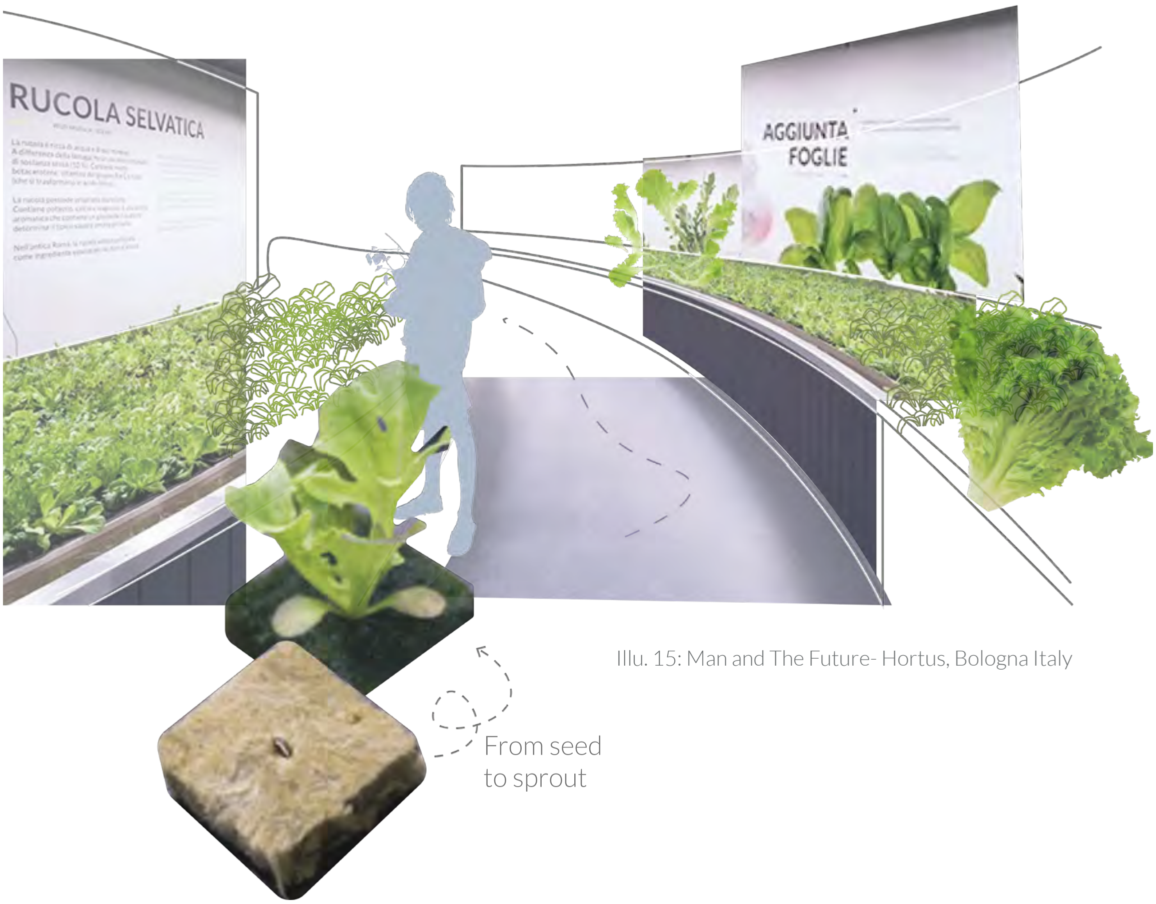
Agriculture has shifted to a more complex focus on integrating food, health, sustainability, and social equity outcomes rather than maximizing productivity. Social sustainability has grown to a larger focus.

Today, a large part of the public is food illiterate, being used to prepackaged meals and year-round fruits and vegetables in the grocery stores. People have lost the connection between production and the food on the table. A large part of the public need education about the food on the table, which is where food literacy is essential. Through education of the public, it is important to take a step back and consider, "Just what is food?" (Nordahl, 2014).

An important aspect of creating a successful public food production is to provide diverse foods reflecting the diverse citizens. Learning about new fruits and vegetables will expand the public food vocabulary, which is good for the community and culture. There is a need for culturally acceptable produce to include a more racially and ethnically diverse customer base. At its base,

"food literacy has much to do with an understanding of culture and ethnic diversity, and which foods have meaning and value to the diverse racial groups that comprise our communities" (Nordahl, 2014).

Summarizing the section, the future development of Grobunden will contribute to supporting the aspect of social sustainability by integrating and focusing on food literacy and contributing to the expanding the knowledge surrounding our food systems. And additionally promote to social services through its functions and programming. .



Illu. 15: Man and The Future- Hortus, Bologna Italy

CASE STUDY

“Man, and The Future – Hortus”

Established by:	Architect Carlo Ratti in Collaboration with FICO
Location:	Bologna, Italy
Year:	2017

Man, and the future – hortus” was a pavilion presented at the fico Eataly world in 2017 in bologna, Italy. Architect Carlo Ratti in collaboration with Fico designed the interactive pavilion articulates the present disruptive vision of our food system.

“Those of us who grew up on a farm know the feeling of planting a seed and then obsessively checking on its progress each day. It’s like discovering the magic of life as it progresses”
– Carlo Ratti (https://carloratti.com/project/fico-area-del-futuro/, 2017).

The pavilions basis was to let anyone in the urban city experience this feeling. The Circular pavilion leads visitors in a space of greens, where the flow follows the progression of the vegetables from seed to plant. By the use of present technologies, sensors can measure the seeds progression so visitors can follow the growth digitally until harvesting. The pavilion utilizes hydroponic farming where basil, curly lettuce and butter lettuce can be grown.

This case will be used as an inspiration for the future development of the cultivation center. Hortus pavilion supports the thesis ambitions of integrating functions that enhance food literacy, through interactive exhibitions which both can enhance knowledge and experiences surrounding food.

CASE STUDY

Østergro

Established by: Kristian Skaarup,
Livia Urban Swart Haaland,
and Sofie Brincker
Location: Copenhagen, Denmark
Year: 2014

Situated on the top of an old car auction house in the center of Copenhagen is Østergro. Founded in 2014 as the first rooftop farm in Denmark (Østergro, 2022). Inspired by roof top farms in the US, it serves the multipurpose of being an urban roof top garden with 600 m^2 of organic fields of vegetables, greens, fruits and herbs, as well as a greenhouse, henhouse and beehives. These are supposed to provide the locals with fresh produce.

The urban gardens work as a community supported agriculture, where members can pay for half a harvest season (April to mid-December) to get a weekly share of the fresh harvest. Other interested can join every Wednesday, where they have volunteered day where they in return for help and caretaking of the gardens offers a vegetarian lunch together. They also hold workshops, events and markets to strengthen the community.

In addition, Østergro, has their own restaurant, Groeatery, where people can enjoy their food in the unique surroundings of the green gardens with an overview of Copenhagen.

Østergro is a relevant case for this thesis as it acts as an inspiration to the future development of Grobunden with its functional purpose as well as its focus on food literacy and social focus with the locals and visitors making it an experience and educational part to grow produce. Moreover, the case can be used as an inspiration to enhance atmosphere and spaces with the use of agriculture, where the different stages of the growth cycle can support a diverse experience.

Illu. 16: Østergro, Copenhagen

CONCLUSION OF THE THEORETICAL APPROACH

Through the medium of the theory and acquired knowledge, a fundamental understanding of the relation between agriculture, urbanization and architecture is investigated and will create the foundation of the analytical approach of this thesis.

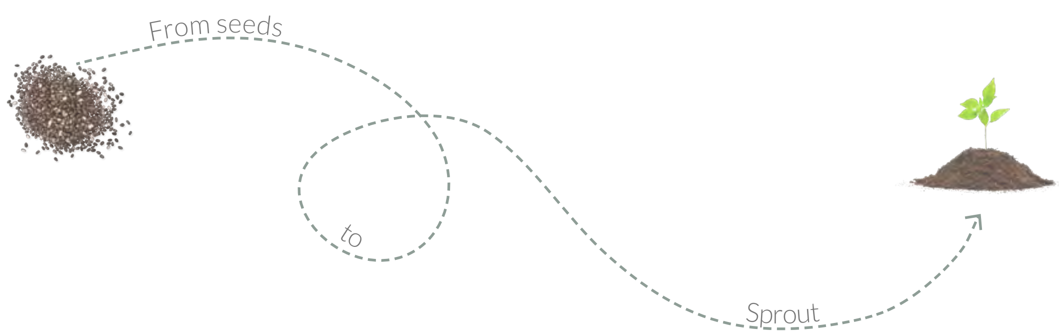
The ongoing rise of population comes with expanding cities, where the need to feed humans change our untouched nature into large areas of cultivation. The construction of the dense city grows rapidly because of quick and generic building methods leaving voids and other urban spaces neglected or demolished.

In acknowledging and understanding these global issues this project sees potential of design an architectural solution through its typology which will address these issues.

The future architecture needs to act as a catalyst for its surroundings both physically as well as socially.

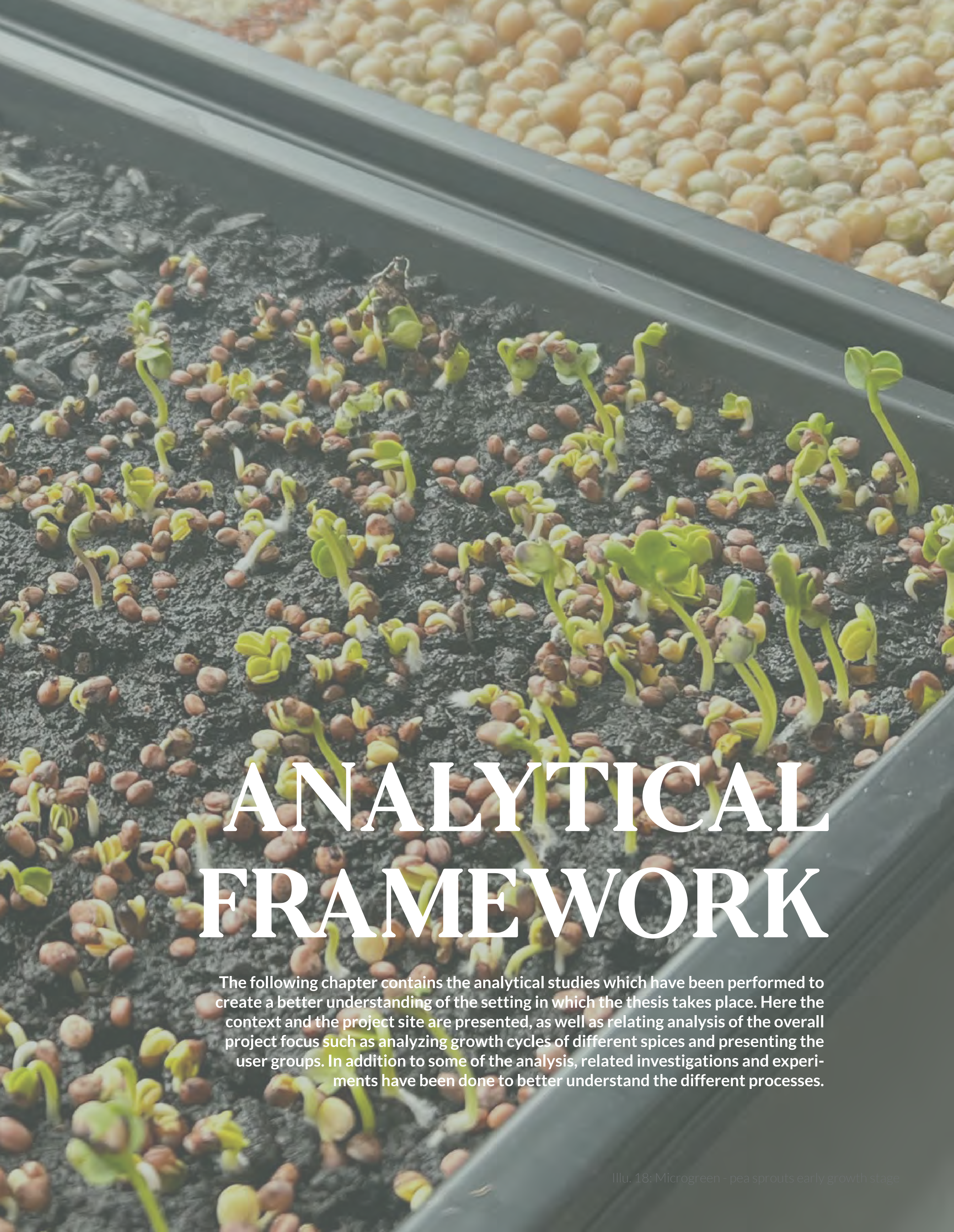
It needs to promote change and ensure sustainable development, where the goal is significantly influenced by material choice. By understanding architecture as part of a larger system of society, there is a potential in critically rethink the way of utilizing materials in a spatial approach of aesthetics, construction, details to amplify the spatiality of an experience. With the means of quality over quantity.

These notions constitute a critical method of evaluating the experienced value of the built.



Illu. 17: Diagram of progression


03



ANALYTICAL FRAMEWORK

The following chapter contains the analytical studies which have been performed to create a better understanding of the setting in which the thesis takes place. Here the context and the project site are presented, as well as relating analysis of the overall project focus such as analyzing growth cycles of different spices and presenting the user groups. In addition to some of the analysis, related investigations and experiments have been done to better understand the different processes.

Illu. 18: Microgreen - pea sprouts early growth stage

Illu. 20: Kirkegaard, J. A. (1953) Børn leger på Sauers Plads (Trækbanen) CC AalborgStadsarkiv

Illu. 19: Arial Picture of Aalborg 1960-1965 CC AalborgStadsarkiv

The History of Aalborg

In the 18th century, Aalborg evolved into an industrial city with tobacco factories and distilleries and with the discovery of chalk in the grounds around Aalborg, the cement industry emerged. In the end of the 19th century, the town experienced a period of growth both in population and industry. This growth resulted in the second largest harbor in the country (den Digitale Byport: Danmarks Købstræder, 2012).

The population has grown since 1990, and Aalborg has advanced into a modern city with a university established in 1974 and a population of more than 100 thousand. Today it is the largest city in northern part of Denmark and is known as a cultural and historic city with a waterfront filled with architectural buildings. The population has an overweight of younger people in the age group 18-35 reflecting the university´s influence on the population (Aalborg Kommune, 2022).

Today, Sauers Plads is part of a collected area enclosed by Jyllandsgade, Dag Hammarskjølds Gade, Toldstrupsgade, Thomas Boss Gade, and Kjellerupsgade. It is part of the area “De Sauerske Grunde” (the grounds of Sauer), which was an empty area until the 1960´s.

It is unusual for an area as central to be empty for so long and still to this day be as open as it is. Around 1885 the area was used for military purposes. A towpath running through Sauers Plads connected the train station in Aalborg with the harbor areas along Limfjorden. A horticultural farm was located on the grounds in the beginning of the 19th century, and it was possible to watch kids playing on the undeveloped plots up until the 1950´s.

In 1905, Sauers Plads was donated by Thomas Boss Sayer and in 1949 plans were developed for “De Sauerske Grunde” to be buildings with public purposes. The police station, the fire station, and the city social administration building were established. The plan was to establish even more public buildings, but the need for more parking in Aalborg changed the plans. A large area was reserved for parking. A characteristic for the area is its unusually many sycamore trees, which normally are not seen in those degrees of altitude. The trees are a green characteristic for the area (Aalborg Kommune, 2004).

This thesis intends to follow the idea from 1949 of creating more public buildings on “De Sauerske Grunde”and contribute to this idea.

Urban Catalyst

“The term covers architectures ability to connect with place, setting out a new framework for the sites use and heling to transform places as both a physical and a social construction.” – Hans Kiib & Gitte Marling, Catalyst Architecture (Kiib and Marling, 2015).

Kiib and Marling addresses the expression of catalyst architecture to regard; architectural developments, which by their placement in a context together with its program, have the positive ability to affect the physical dynamics of social or cultural change.

An analysis of Aalborg found several spaces which have this ability. The city has several known spaces where people gather for different activities and purposes. Some examples of these spaces could be Friis Shopping mall with the related Gables square, or Stjerne Pladsen and lastly Budolfi square where food, stores, and programmed zones invites for leisure and social gatherings which enhances the livability of the space.

The city is filled with many programmed areas and parks which all have different characteristics and invitations for different activities which attract people. Apart from these places there are cultural spots; Musikkens Hus and Nordkraft which could also be characterized as urban architectural catalysts. Here the built environment with its surroundings can seem less programed, but with the architecture’s mixed function it has the ability of changing the spaces to generate activities to contribute to life. As an example, transforming the space in front of Musikkens Hus to host an outdoor concert or event.

Furthermore, it is important to know what is needed for places to become an urban catalyst and attract people. It cannot just be a one-time experience for the customers or visitors. The place must become a regular place of visit for the locals. Therefore, the relations between programs, functions and the user are a crucial factor for enhancing life.

“Architectures ability to affect the physical dynamics of change in the built environment; similarly, it includes both architecture in use, as an experienced structure, as well as the impact it may have on changes in behavior and perception of place.” – Hans Kiib & Gitte Marling, Catalyst Architecture (Kiib and Marling, 2015).

Summarizing the aspects of the analysis, this thesis aspired to use inspiration from these public spaces to transform the parking house and develop architecture that enhances for a physical, socially, and cultural change of the current Sauers Plads parking house to attract visitors through its focus of food literacy and food production.

Illu. 21: Urban Catalysts, 1:10,000

Illu. 22: Budolfi Plads, Aalborg

CASE STUDY

Budolfi Plads

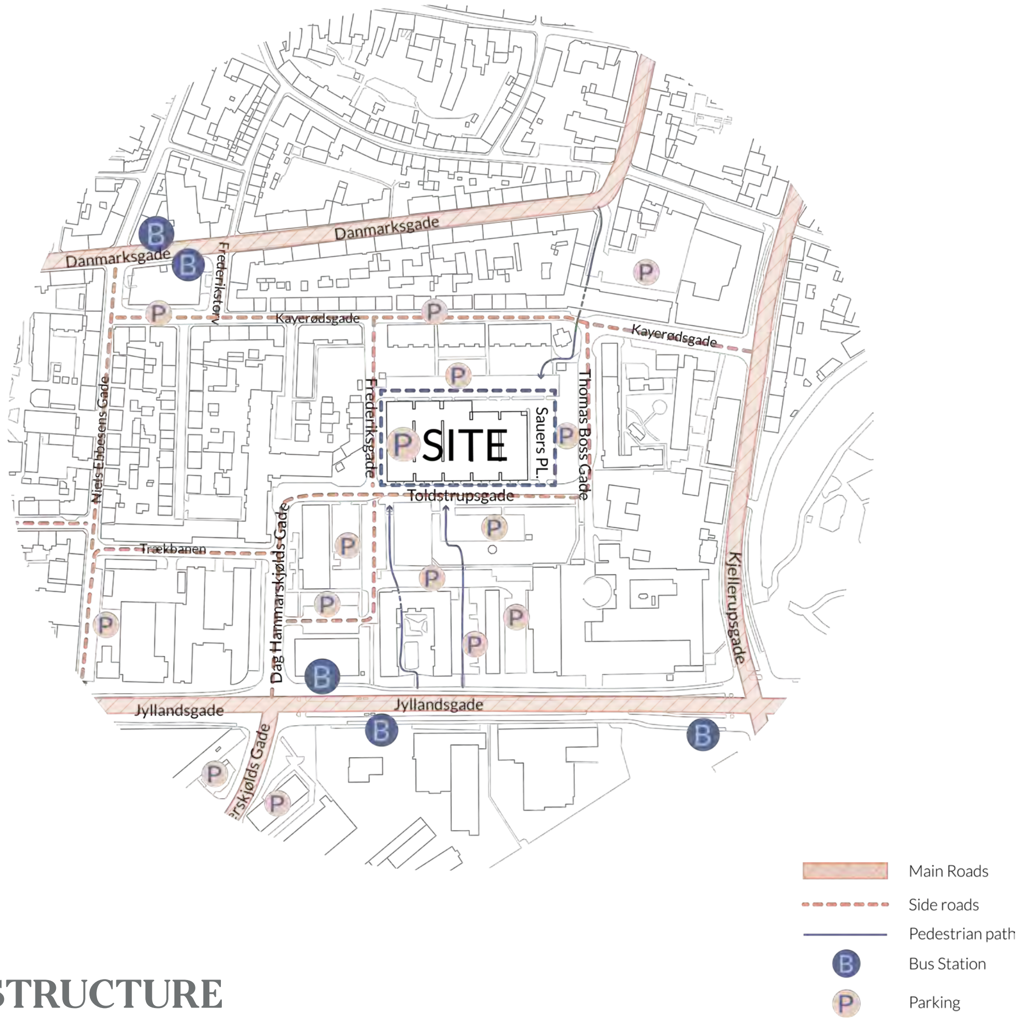
Architects:	Ole Madsen from Kjær & Richter, SLA Landskabsarkitekter, ÅF Lighting
Location:	Aalborg, Denmark
Year:	2019

Budolfi Plads is a hybrid spot in the center of Aalborg next to Budolfi Church, Aalborg History Museum, and the old post-office from 1910. The plaza was intended to be the city´s central spot and meeting place. During the Second World War it was used as an emergency shelter, before it was converted into a grocery store and a parking lot in the 1960´s.

In 2015, the municipality worked towards changing it back to its original vision. And in 2019, Budolfi Plads opened for the public as a green space including a restaurant and with parking underneath with a connecting grocery store.

The plaza is centrally located, connecting two of the shopping streets in Aalborg. Apart from the historic buildings, apartments and businesses surround the plaza. The plaza is a focal point attracting people, making sure the area is always filled with life (Aalborg Kommune, 2019).

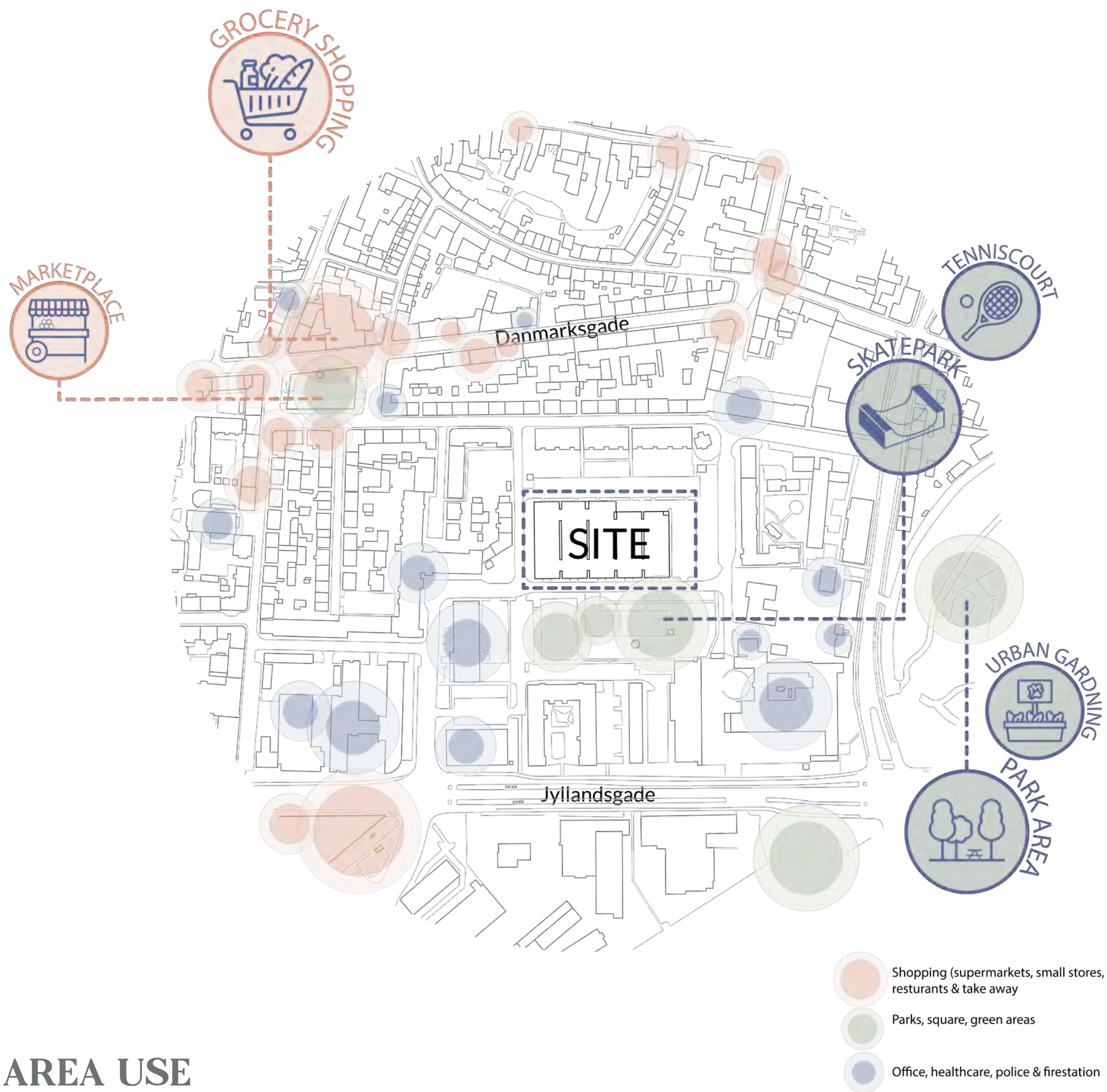
This renovation shows an example of how a “wasted” space in the city can be transformed into a green and useful space connecting the surrounding functions and become a central meeting place for the residents. This is important as city´s become more and more dense brining businesses, residentials, parking, and parking closer. The importance of utilizing every area in the city is increasing and creating a need for new solutions.



INFRASTRUCTURE

Illu. 23: Accessibility and infrastructure, 1:5000

The location of the site lies hidden from the busy main roads, Jyllandsgade, Danmarksgade and Kjellerupsgade, with only a smaller road leading into the parking area creating a shelter from the traffic and noise. Near the site there are great public transportation opportunities both by bus and the nearby train station which is less than one kilometer away.
The new bus line "plus bus" stops on the main road of Jyllandsgade, where it is possible to walk across towards the site. Furthermore, there are bike paths along the main roads creating a safe route all the way.
The smaller roads are bike friendly due to the speed regulations.
The site is surrounded by parking and minor roads, on the east side of the site tourists arrive by Flixbus which parks along Thomas Boss gade. Mapping the different surrounding infrastructures creates an understanding of the current arrival possibilities to the site. Currently, there are three approaches to the site, one from each of the following corners: south-west, north-east, and north-west corner. These three approaches are seen to be incorporated into the project to create the arrivals and bring people onto the site.



AREA USE

Illu. 24: Area use, 1:5000

The project location is situated within a mixed urban area with functions consisting of residential buildings, food-related shops, and stores. The maps indicate the wide variety of small shops, takeaway spots, supermarkets, vegetable markets around Danmarksgade, but when looking at the south of the site it suddenly becomes a food-desert with functions of residential blocs, office spaces, and parks.

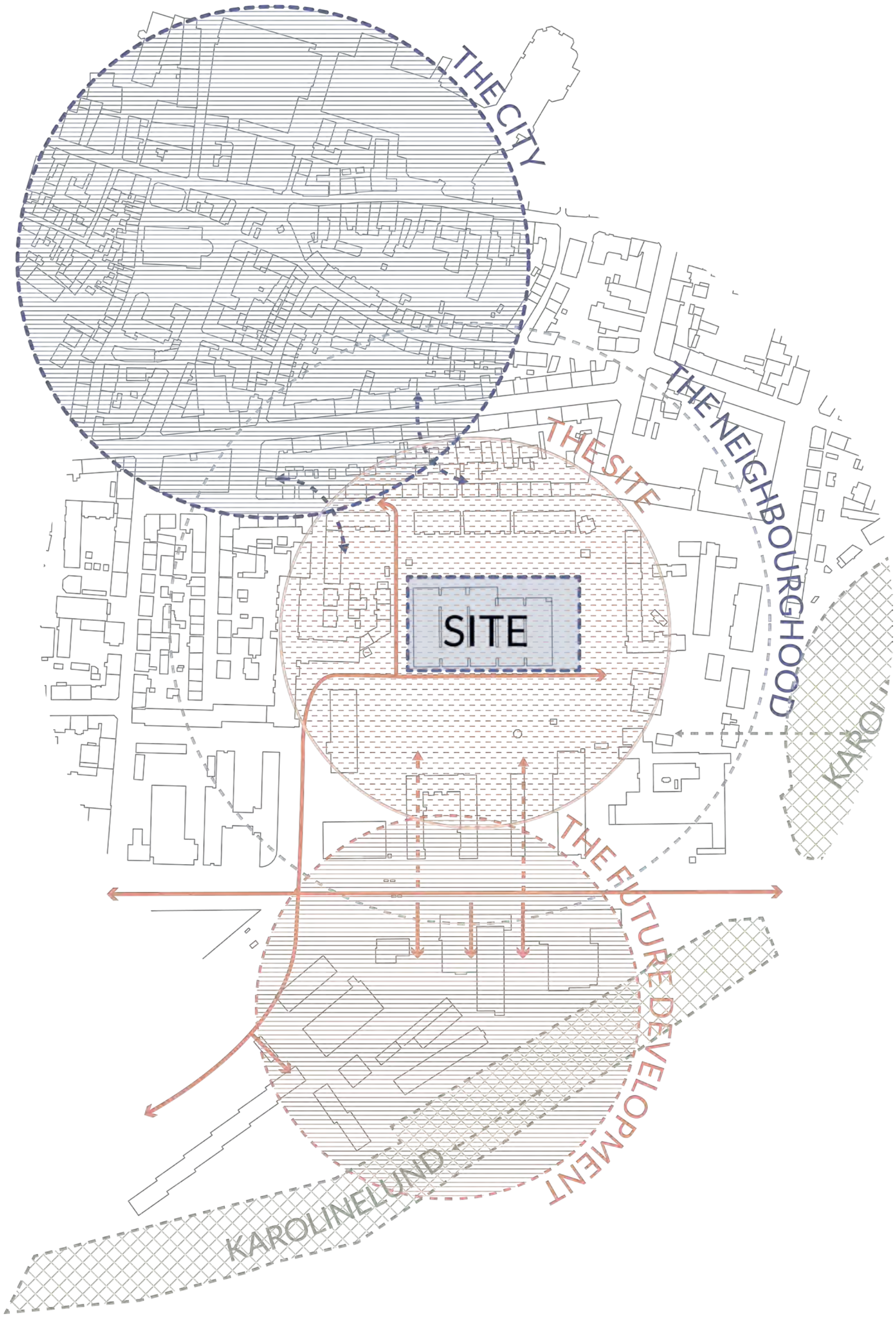
Therefore, this might suggest the potential to implement a new urban spot, which with its architectural program can contribute to the local neighborhood and the daily employees of the area and provide to a multi-cultural and cultivational services to generate more life.

THE EXPANDING EFFECT

In relation to the area use of the neighborhood, a new master development of Åparken and Hjulmagervej is currently being built. The future of the area will consist of multiple residential buildings, office spaces, shops and green areas (Aalborg Kommune, 2016). As this development lies opposite the site location gives the suggestion for the architecture to become a link between the area.

Furthermore, Karolinelund which is east of the site is undergoing a transformation into a recreational area with blue and green structures, the plan is to keep the use as a green park area with different activity opportunities as pétanque, volleyball courts, an urban farming area, playgrounds and in the summer, it is utilized for outdoor concerts.

Through the acknowledgement of these new future developments near the site, a new building could constitute to creating a connection between the old residential area, the city and the future development and act as a new urban generator and catalyst in between the built environment.



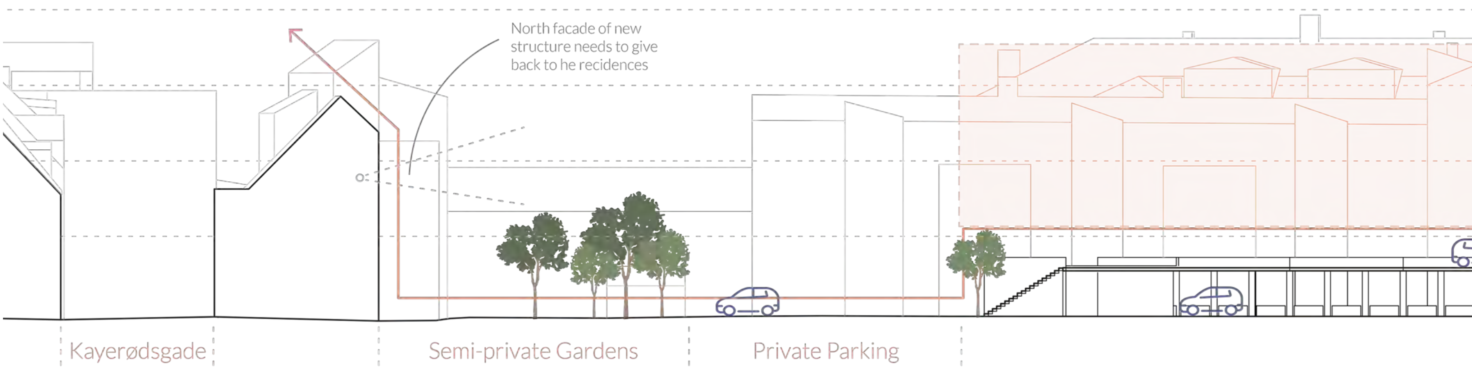
Illu. 25: The expanding effect, 1:5000

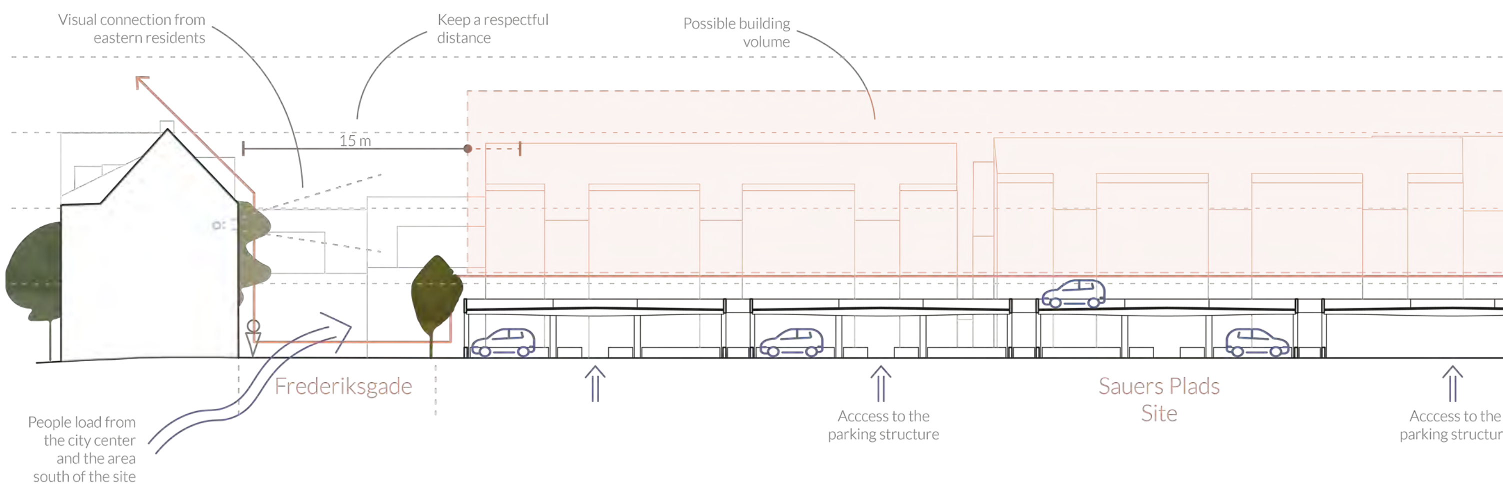
THE SURROUNDING SCALE

The surrounding buildings are an important factor in the development of the new urban center. The existing buildings surrounding the parking lot leave a large open space with tennis courts, skater park, parking, and green areas. It is one of the least dense areas within the center of Aalborg.

There is an opportunity to add more height to the center of this space, while still contributing to the park-like identity. Especially, the surrounding buildings' heights contribute to why the space feels like a void in the city.

In addition to the building heights, all four sides of the parking structure have different characteristics, suggesting different approaches for each side. The area in front to the south is a larger open area with skating ramps, parking, tennis, and some green spots.
The distance to the nearest building is the largest in this direction. Whereas the distance to the building on the west side is relatively short, creating a different environment. On the north and east side, there is parking, grass, and trees before the residential buildings.



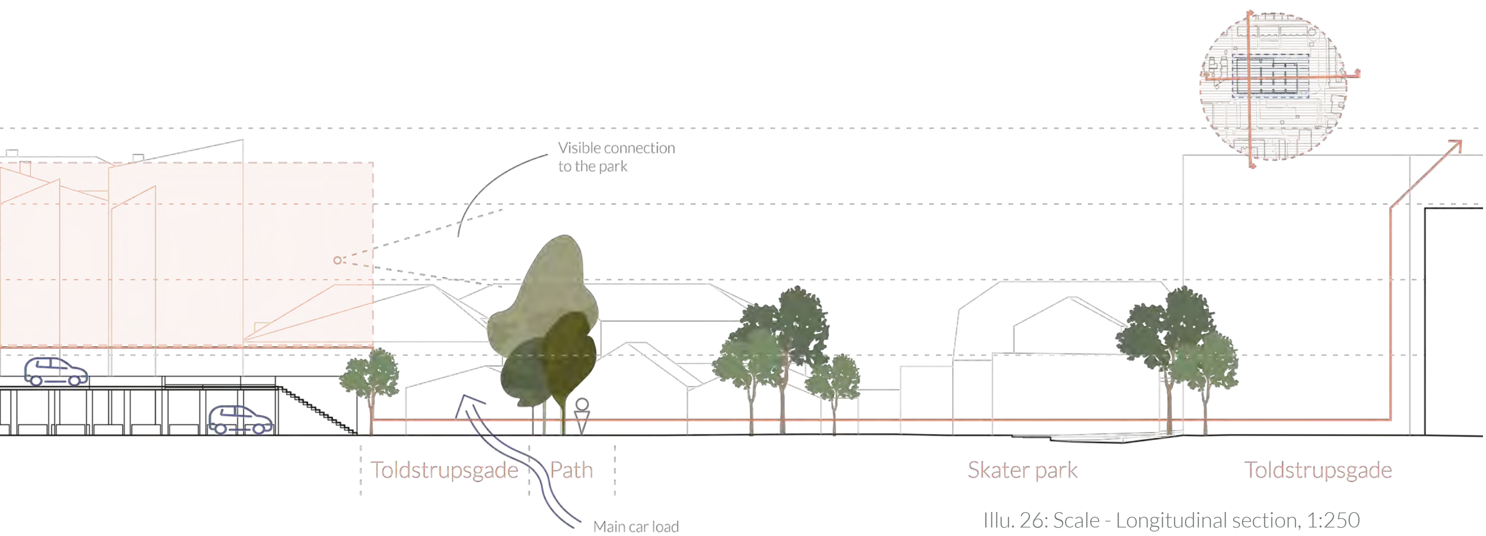


These two sides already have a green "buffer" zone between the residential buildings and the parking structure. The difference here is how the new building can affect the daylight and views for the apartments on the north side.

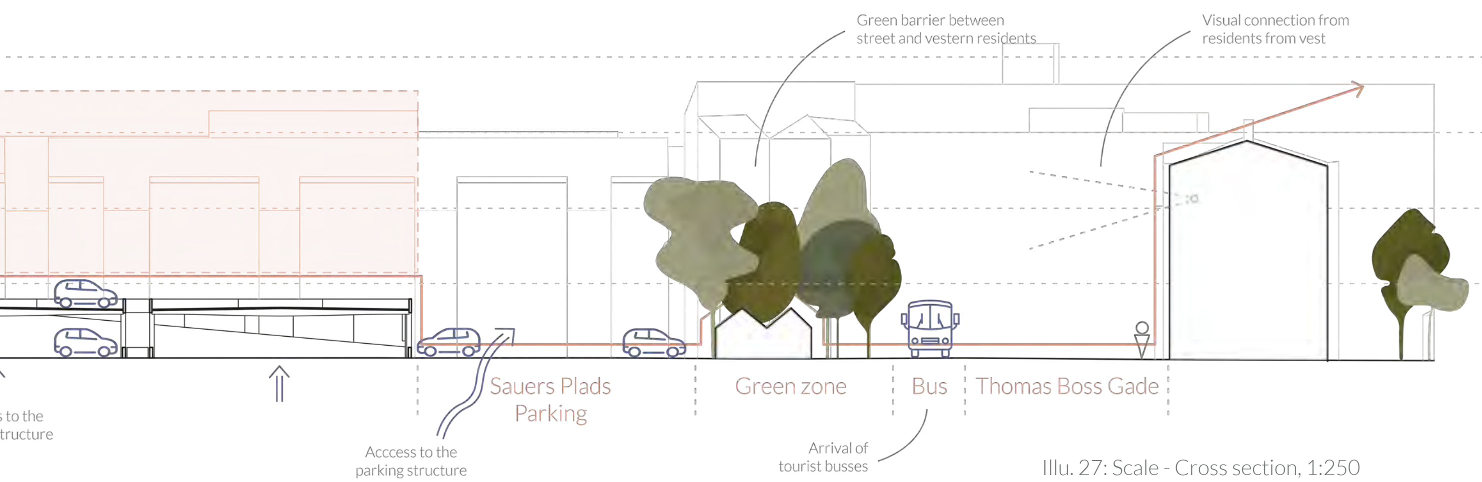
In conclusion, currently the site has an identity as a parking island in one of the least dense areas in the center of Aalborg.

The new building needs to respect and consider the surrounding residential buildings both in height and in distance, while creating a connection to the open area towards the south.

Lastly, the design needs to be integrated with the surroundings while standout in appearance to enhance its function as a public place in town.



Illu. 26: Scale - Longitudinal section, 1:250



Illu. 27: Scale - Cross section, 1:250

INVESTIGATION:
ARRIVAL PRINCIPLES

The study investigates different possibilities of arrival and entrances to the site. In connection to the previous analysis of the infrastructure of the site, followed an early iteration of the arrival to the site to conclude possible entrees to the building. Here different access points were considered through the existing flow, the new flow and their connectivity in regard to the space which they created.

Firstly, one entrance towards the west was considered to enhance one main access to the building and designing one public stairway to go up to the building.

This proposal only considers the flow from Frederiksgade which creates a backside from the other sides of the site. The new flow would moreover become very one-sided. This led to the proposal of having two arrivals points.

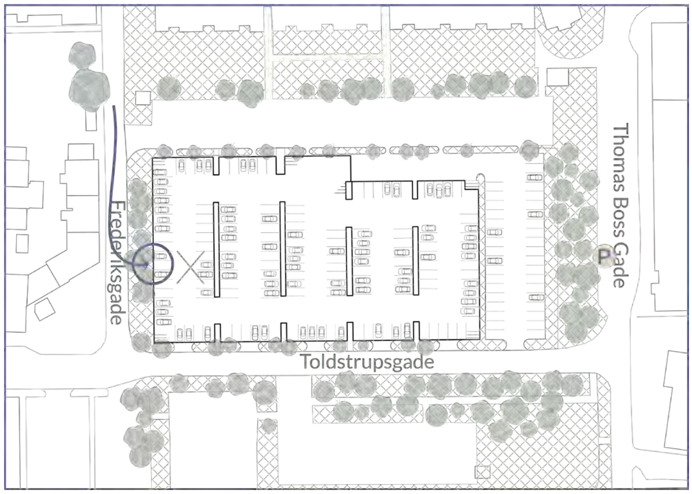
Implementing two sides of arrivals considers the existing flow more and enhances a flow from both sides of the site. Adding an entrance towards the east of the site meets the users coming with the flix bus and from the outside parking area, though it would not be optimal to place the arrival in the center of the site as this in connection to the other arrival towards the west creates a highway situation.

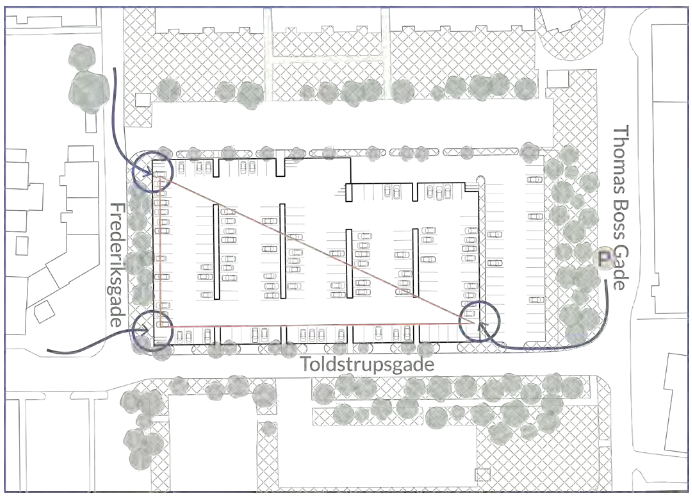
Furthermore, this placement is not optimal as this would invite the user to cross an embarkment onto the outdoor parking area. Moreover, the placement of the western arrival point was challenged after another visit to the site, where it was observed that there was a large flow of pedestrians from the northwestern corner, this then led to the proposal of creating a third entry and moving the eastern.

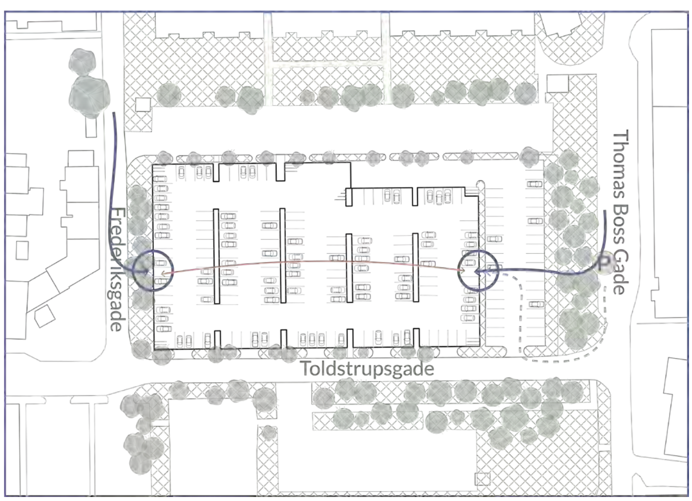
As seen on the third proposal (illu. 28), three arrival points create more circulation around the site considering the flows from all sides. By having two access ways on the west side corners take into account the flow from the center of Aalborg and the future flow from the new development towards the south of the site.

By creating three arrival points, the flow and infrastructure of the users around the site is considered. The three accesses point also create an interesting flow onto the site which could be further investigated with the placement of functions. Furthermore, with inspiration from Bodulfi plaza these arrivals will have their own characteristics and uses to create different experience when arriving from each point.

Considering the current minimal pavements around the site, it is evident that new ones need to be made to create a safer environment for the pedestrians. Furthermore, it will be investigated how to transform Frederiksgade into a street with reduced speed where the pedestrians are in focus, and which could create a more urban connection to the city and between the two access points in the east.







Illu. 28: Investigation - arrival principles

SURROUNDING MATERIALITY AND TACTILITY

The surrounding structures and buildings in the nearby area consist of diverse expressions and details. A perceptual exploration of the facades generates a more phenomenological understanding of the surroundings. The material mostly consists of bricks, where the conditions tell a story of the building's life.

A clear contrast of new and old is also seen in the material change and ornamentation of the buildings, a tactile variety of concrete elements, stucco foundations, thin metal plates enhance the understanding of the change which many of the buildings have gone though.

Accumulating this analysis, it is aspired to drag inspiration from the surrounding materiality and enhance the tactile sense through the interplay of materials and form. Moreover, utilizing materials to translate the use of the building and support the typology as an urban catalyst.

Illu. 29: Photos of the surrounding materials

AN URBAN PARKING LOT IN AALBORG

The project site is located at Sauers Plads in the city center of Aalborg. The site currently consists of a two-story parking area. The site is interesting because of its central location in Aalborg and its mono-, almost non-functional purpose of parking cars, while the surrounding buildings are leaning their backs up against the site. This leads to the impression of an empty space in the middle of the city, where the parking area becomes this parking-island with a dead façade towards the surrounding area.

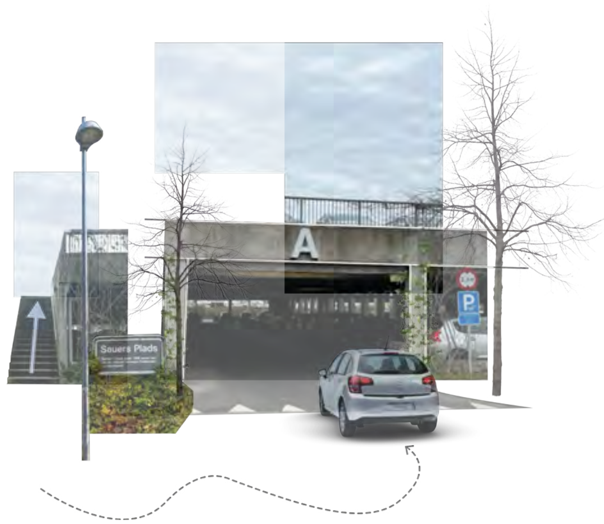
The parking area has the potential to become a multi-functional typology and contribute with new functions into this part of the city as it is situated on the edge of the city center, near new- and future residential areas, like Godsbanen, Åparken, and Hjulmagerkvarteret, and green spaces like Karolinelund.

The current situation of the parking area leaves an unexplored potential for introducing functions like this project´s cultivation center for urban farming as it lies within an area with many different food related shops and stores. Especially on a street like Danmarksgade, there is a wide variety of specialty shops and stores, takeaways, supermarkets, vegetable market etc.

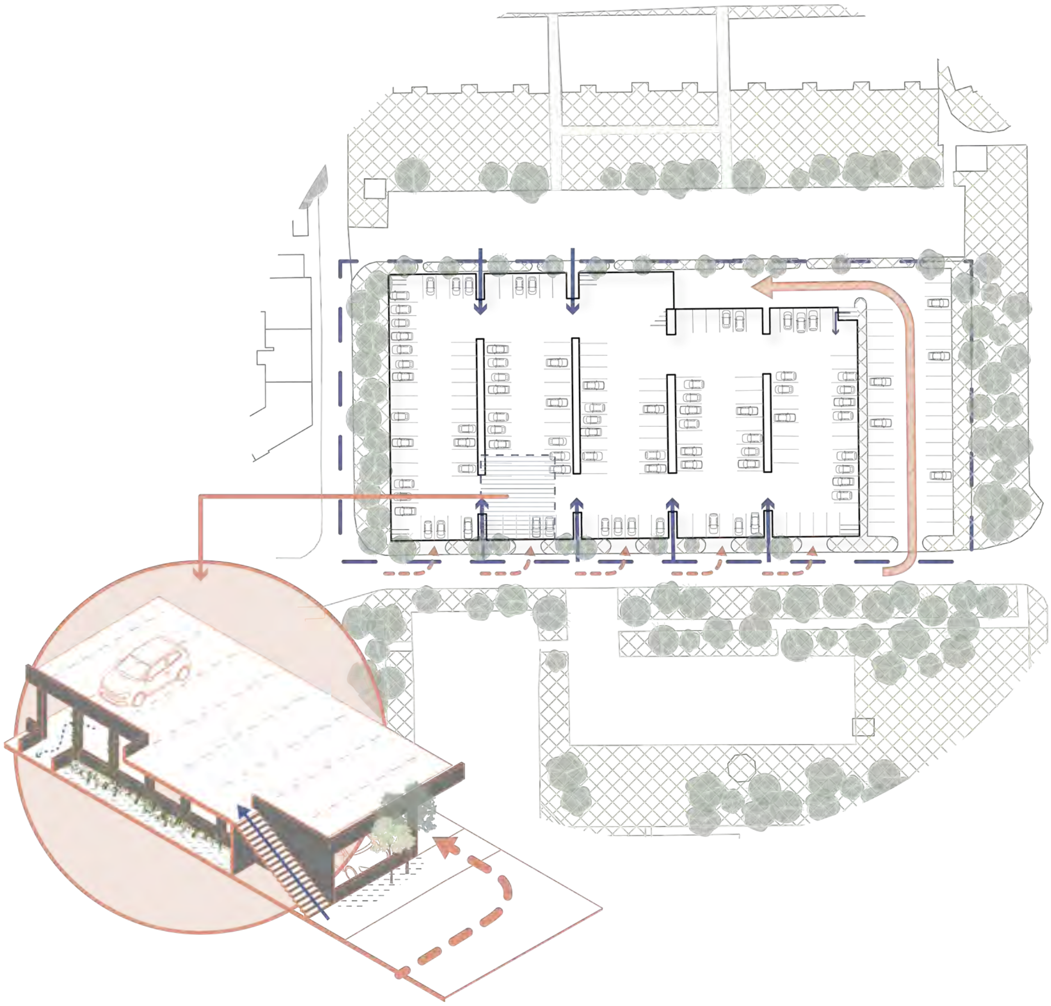
But when looking south of the site, the area suddenly becomes a food-desert except for a few supermarkets and a single restaurant. This situation makes sense now, as Åparken and Hjulmagerkvarteret has not been developed yet, but when looking at Godsbanen from 2018, it is obvious to see that it has not been possible to add these needed functions like cafés, shops, etc. into the newly developed area.

SITE INFORMATION

Total parking spaces:	365 parking spaces (inkl. 5 handicap) + 6 motorcycles.
Total footprint:	4900 m^2
Year of construction:	2012
Material:	Pre-cast concrete



Illu. 30: Sauers Plads illustration



Illu. 31: The Urban Parking Lot Illustration, 1:500

This means there is a potential for building a connection between these residential areas and the city center as these new areas are relying on the functions the city provides due to the lack of these functions where people live. Therefore, the cultivation center will be a link in the connection.

Sauers Plads parking area, with its location, almost acts as an empty and unused courtyard to the surrounding residential buildings, and this suggests the potential of creating a space which can be useful for the locals as well as visitors and therefore become an urban catalyst.

INVESTIGATION:
STRUCTURAL PRINCIPLES

In correlation with the site analysis, the question of how to build and construct a new typology on or over the existing construction needs answers. This led to investigations of different possible structural solutions. The existing parking structure was built to carry an extra parking deck of what exists now, giving the opportunity to place some of the loads on the existing structure. This being said, it is only possible to place the new roof terrace area directly on the parking deck, because the rest of the building structure and the interior loads especially from the production exceed the strength of the existing structure. Therefore, concept one is not possible.

Based on this knowledge different structural principles were investigated. Firstly, a concept with a grid of columns through the existing parking deck was tested (concept two). This concept builds on the idea of a grid system with smaller spans, but this requires multiple holes in the existing deck and affects the circulation in the parking area.

The third concept with one large core to support the building is a large structural system with bridge-like concepts to carry the loads. A large area of the parking deck will be required to be moved and the structural system is more complex than the other concepts. A further development of this concept is to have two cores. This system is still complex and requires high strength from the two cores going through the parking structure.

These first concepts require changes to the existing structure and the loss of parking spaces. A different approach is to create an exo-system with columns along the exterior facades of the parking structure as well as columns through the light shafts. This leaves the parking structure intact, while giving a strong structural base for the new construction over the parking structure.

Structural span

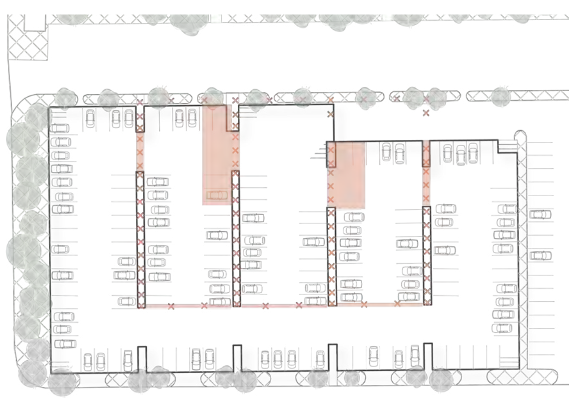
Structural strength

Structural complexity

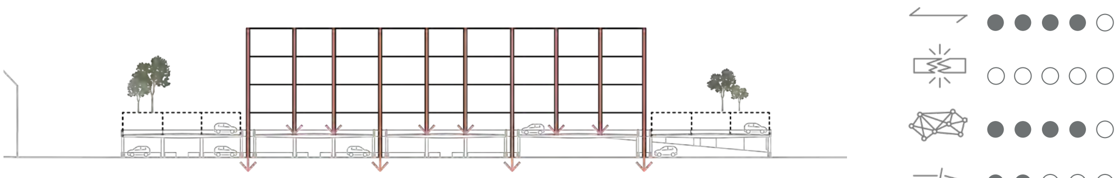
Interference with existing structure

As the exo-system has some critical spots with larger spans and the need for vertical circulation from the parking levels up to the new building, two cores are needed. Therefore, the last concept combines the exo-system with two structural cores, stabilizing the building and brings a direct connection from the parking levels to the new structure. This concept leaves the existing structure as intact as possible. As the plan illustrates, the two cores are the main interference through the construction, while the majority of the columns are placed in the light shafts.

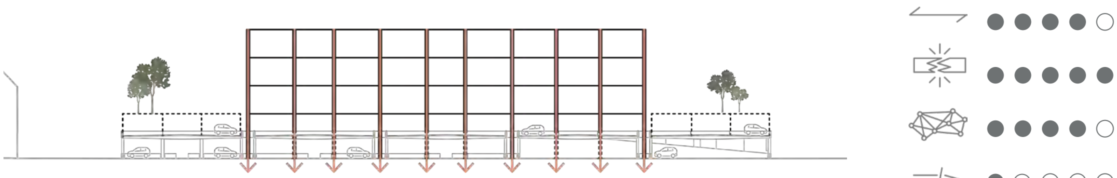
Conclusively, the structural system is utilizing the existing light shafts and taking advantage of the parking structure's modular construction while leaving the structure as intact as possible and consideration of the flow of cars on the decks. The new structural system uses the same principles as the existing parking structure. A further investigation of the structural system will be investigated to get closer to a tectonic solution. Through an investigation of the global warming impact, different construction materials will be compared based on the structural purposes, translation of the typology, and the practicality of the functions.



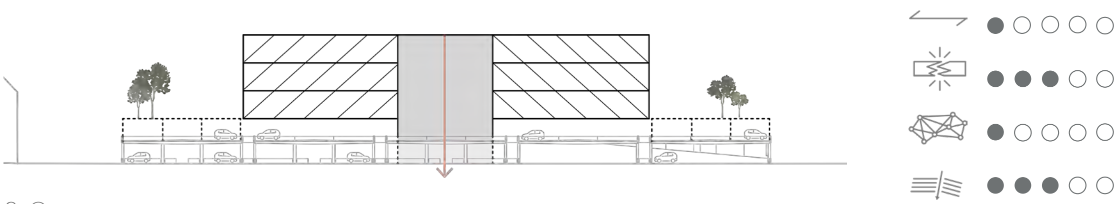
Illu. 32: Structural interception with existing structure



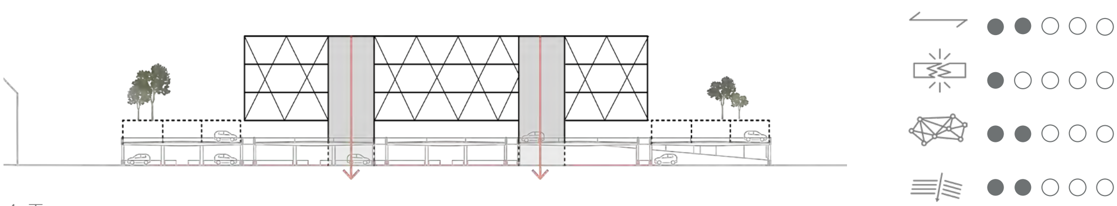
1: Load on existing structure



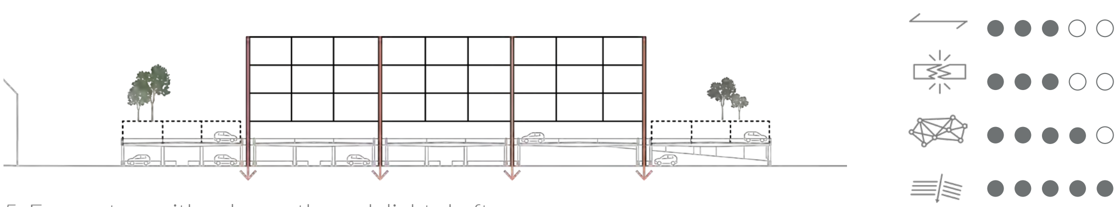
2: Small grid with columns through parking deck



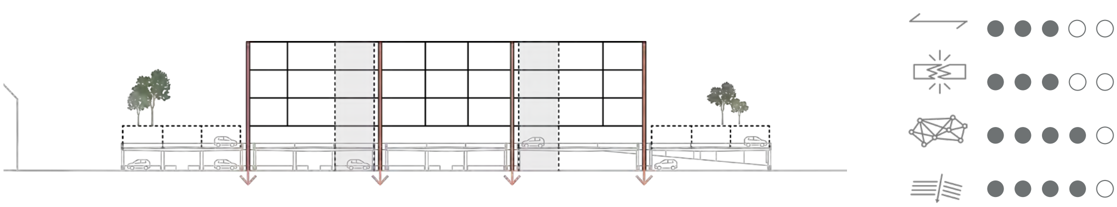
3: One core



4: Two cores



5: Exo-system with columns through light shafts



6: Exo-system with two cores

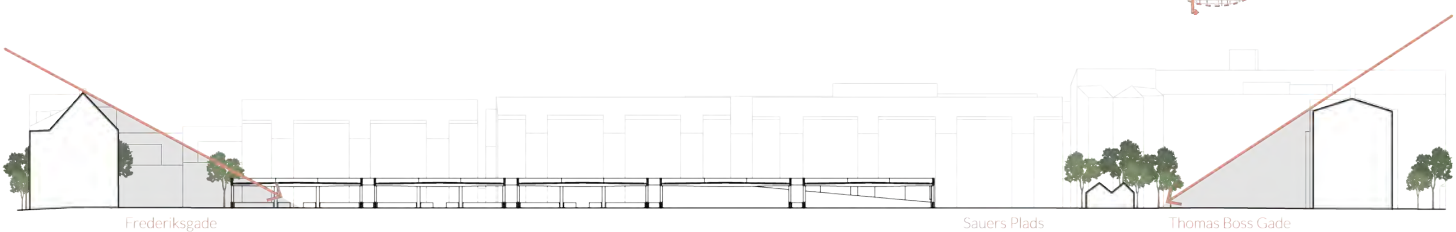
Illu. 33: Structural principles 1-6

Micro Climate

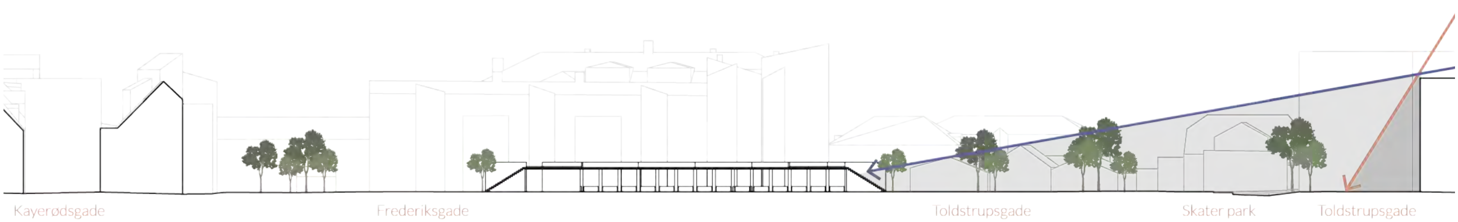
The following analysis will investigate the environmental characteristics of the site in terms of sun, wind, and rain, as these are important factors when designing an urban cultivation center. The Danish weather does not have any periods with extreme weather or sudden changes in conditions.
This being said, the project needs to recognize the differences in temperature and daily sun hours during winter and summer. There are significantly less hours with daylight in the winter compared to the summer. This has an influence on the placement of building volumes, but also on the outdoor functions and the neighboring buildings.

Stronger and a higher quantity of wind comes from west and south-west indicating a need for some shelter towards west and south-west for possible outdoor areas. The monthly precipitation can be utilized through rain collection, which can be used for watering of the different plants and greens on site.

Through microclimatic analysis and gained knowledge of the weather, these have created an understanding of how to practically utilize the sun, wind, and weather in the design, resulting in a more energy efficient and urban cultivating development.

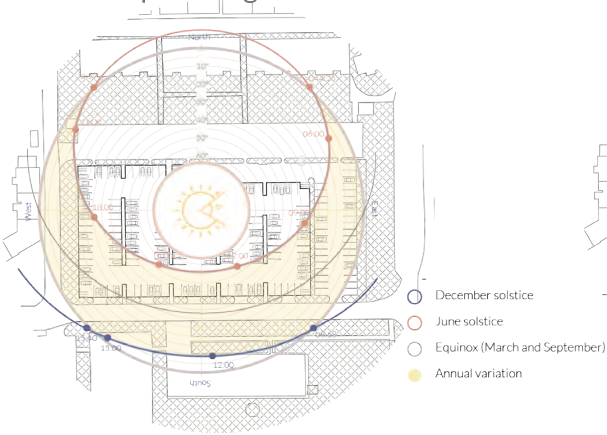


Illu. 34: Sun angles - Longitudinal section, 1:500

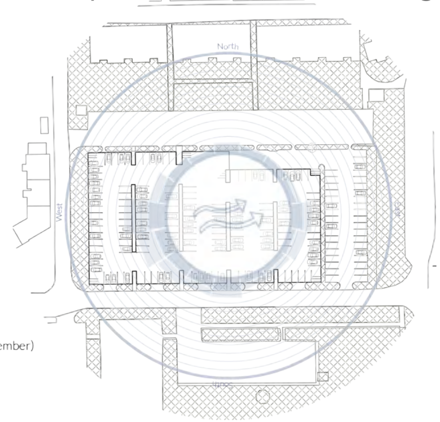


Illu. 35: Sun angles - Cross section, 1:500

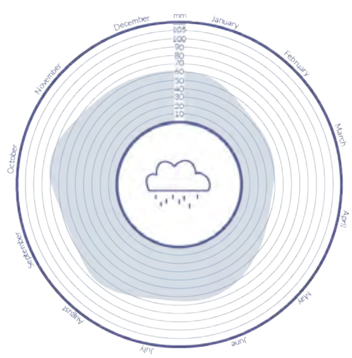
sun path diagram



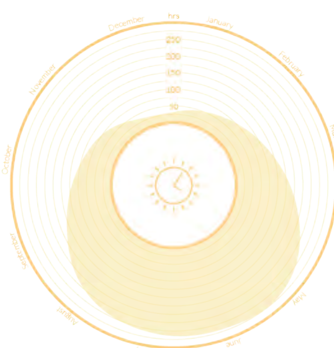
monthly wind direction and strength



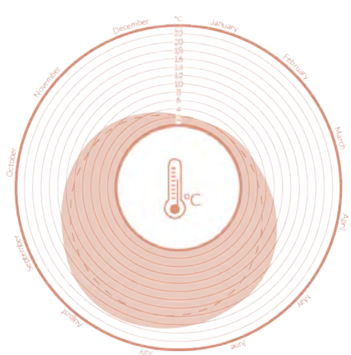
average monthly precipitation



average monthly daylight hours



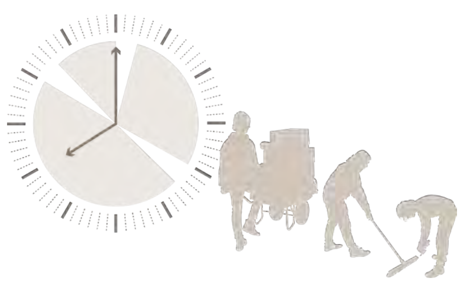
average monthly temperature



Illu. 36: Micro climatic diagrams

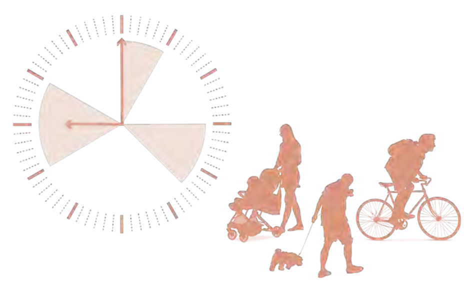
The User Groups

The user of the new typology requires an understanding of who will visit the center. The users have been divided into four different groups, consisting of employees, locals, visitors, and tourists to require an understanding of who, why and when these users will visit the new typology. This will provide an overview of the building's full potential use, so it can become a new meeting spot and act as another pearl on the string of the current city generators in Aalborg.



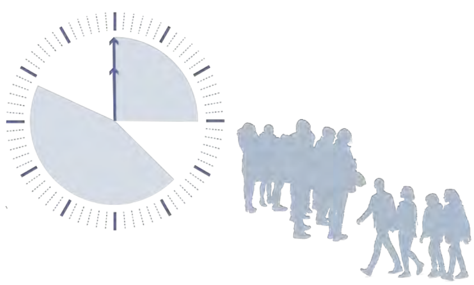
The Everyday Users

The everyday users are fundamental to the new typology as they oversee the operation of the building and its program, these represent people from different backgrounds and education, and work in food production or in restaurants, cafés.



The Weekly Users

Weekly users from the neighborhood constitute to the different types of residents and workers in the near area of the site, these will often come by to eat during lunch or dinner, for shopping the fresh produce in the market hall or to use its facilities for enjoyment like relaxing or nurturing their own urban garden.



The Occasionally Users

The occasionally visitors from the region are the people from Aalborg, this group represents bigger clusters of people like schools, offices or friends and they will mostly use the center for its educational offers, as they can join cooking courses and get hands on experience, or they can join talks and learn about the future of food culture and cultivation methods.

The Seasonal Users

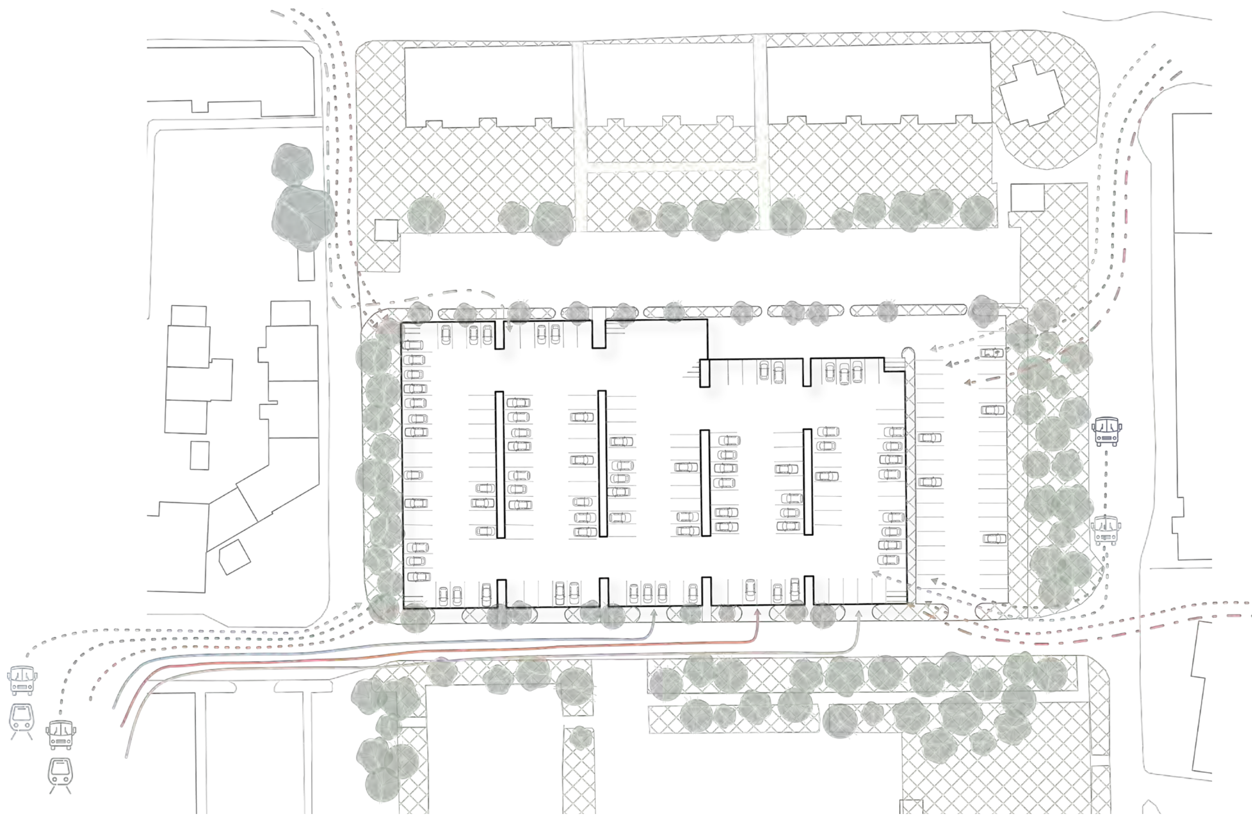
Lastly, as Aalborg is a tourist town, the final group represents the seasonal users coming from cruise ships in the summer or who are on vacation in the city. These will visit the center as an attraction, just like any other beacon in Aalborg, here they will eat lunch or dinner and experience the modern cultivation methods and learn about the food culture.

The clock indicates the time of of the day when the users start to come, whereas the fullcolor illustrates the later hours of activity

Illu. 37: User groups

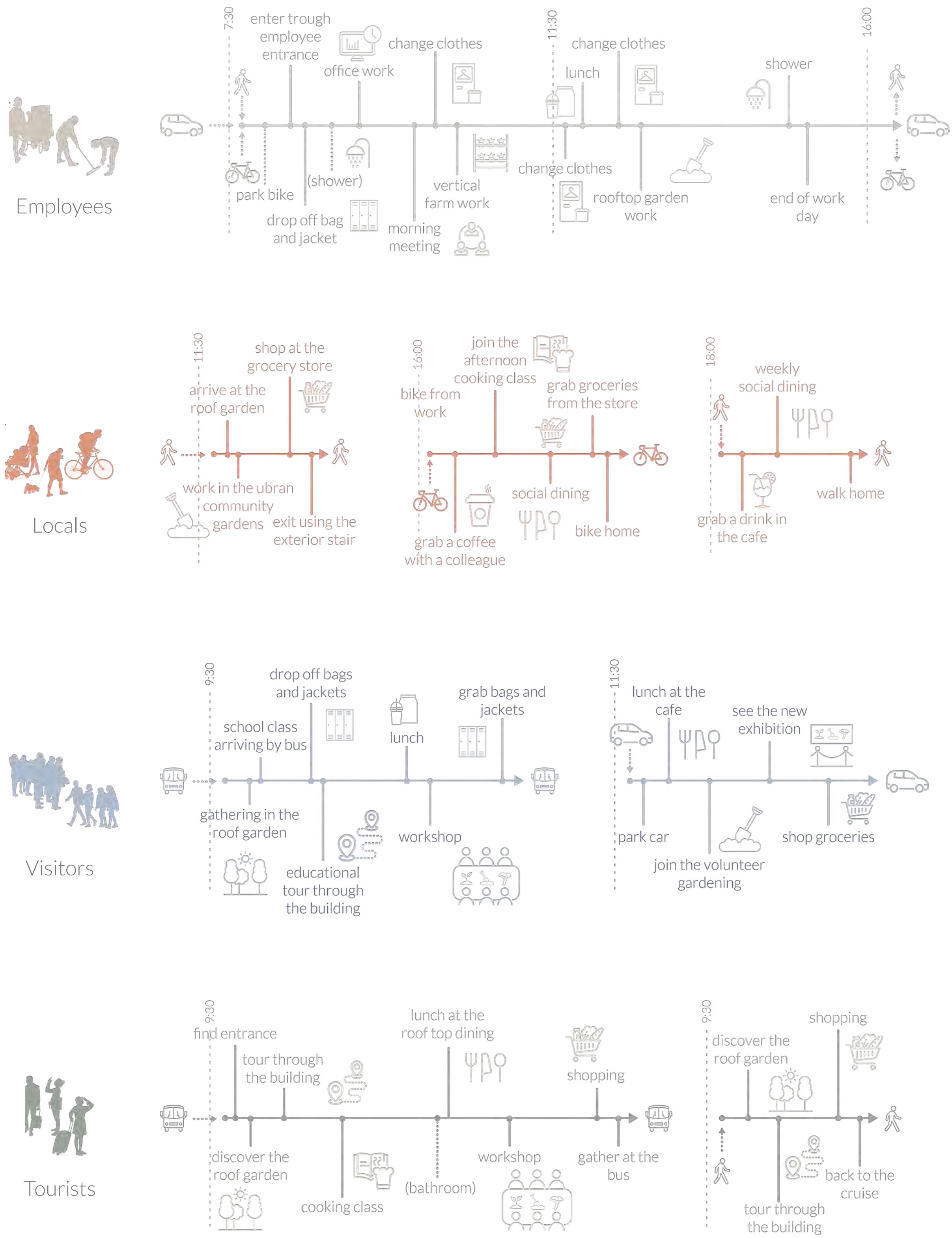
INVESTIGATION:
USER PERSPECTIVES

In continuation of the chosen user group, a user scenario has been created to give an understanding of their individual use of the building from arriving, to being inside and leaving. By setting a scene of the user's day at the building, it enhances a better relation to the use of it and how it can affect both the use throughout a day but also for all year use. Furthermore, it can constitute the future process of organizing the building.



Illu. 38: User arrival plan

As a result of the different user perspectives the programming of the functions needs to consider the weekly and daily users' needs by placing the more public and everyday functions such as the café and store on the first level, while placing the more semiprivate and administration functions further up in the building. With inspiration from Østergro, placing the restaurant on the top floor will enhance activity vertically and act as a roof top dining area for the visitors and provide a more intimate atmosphere.



Illu. 39: User timelines

Room Program

	TOTAL AREA (M^2)	QUANT.	PUBLIC/ PRIVATE	ATMOSPHERE AND EXPERINCE
FOOD LITERACY				
Atrium/Foyer	580		Public	Open area for events, talks, markets etc.
Flexible Exhibition Area	420		Public	For changing exhibitions through out the year
Cooking Class	200		Semi Public	Weekly classes with local greens from the productio
Urban Farming Class	105		Semi Public	Educating in how to grow veggies i urban areas
Hydroponic Farm. expr.	230		Public	Learn about the process and watch the greens grow
DIY - Micro Greens	90		Semi Public	Prepare your own grow kit and bring it home
Mushroom Experience	60		Public	Learn about mushrooms and how they are produced
DIY - Mushroom Grow Kit	110		Semi Public	Prepare your own grow kit and bring it home
CAFÉ	290		Public	Pubic café with greens from the production
Kitchen	35		Private	
Storage etc.	20		Private	
Greens storage	25		Private	The café has it´s own Greens storage on display
RESTAURANT	320		Public	With a view over the rooftops of Aalborg
Kitchen	80		Private	
Storage etc.	15		Private	
URBAN GARDEN SHOP	120		Public	Buy fresh greens or eqiptment for your own prod.
Storage etc.	70		Private	
GREEN HOUSE	215		Public	Placed on the top of the building with a view to the p
PRODUCTION				
Hydroponic Farm (2 levels)	595	2	Private	With sneak peaks to the surrondings through windo
Production Facilities	240		Private	
Microgreens Production	110		Private	With sneak peaks to the surrondings through windo
Production Facilities	60		Private	
Mushroom Farm	155		Private	Visible from the Mushroom experience
Production Facilities	160		Private	
Mircogreens (Parking)	100	6	Private	To increase the attention of the cultivation center
Mushroom Farm (Parking)	100	6	Private	To increase the attention of the cultivation center
ADMINISTRATION				Facilities for the employee
Comon area	105		Private	
Offices	80	2	Private	
Meeting Room	35		Private	
Print/Storage	15		Private	
CIRCULATION	205		Public	
SERVICE		1		
Lavatories	120	19	Public	
Wardrope/Locker	20		Public	
Storage/Service	40	3	Private	
TECHNICAL				
Technical facilities	85	7	Private	
Ventilation	75	7	Private	
TOTAL	5360			

Illu. 40: Room program

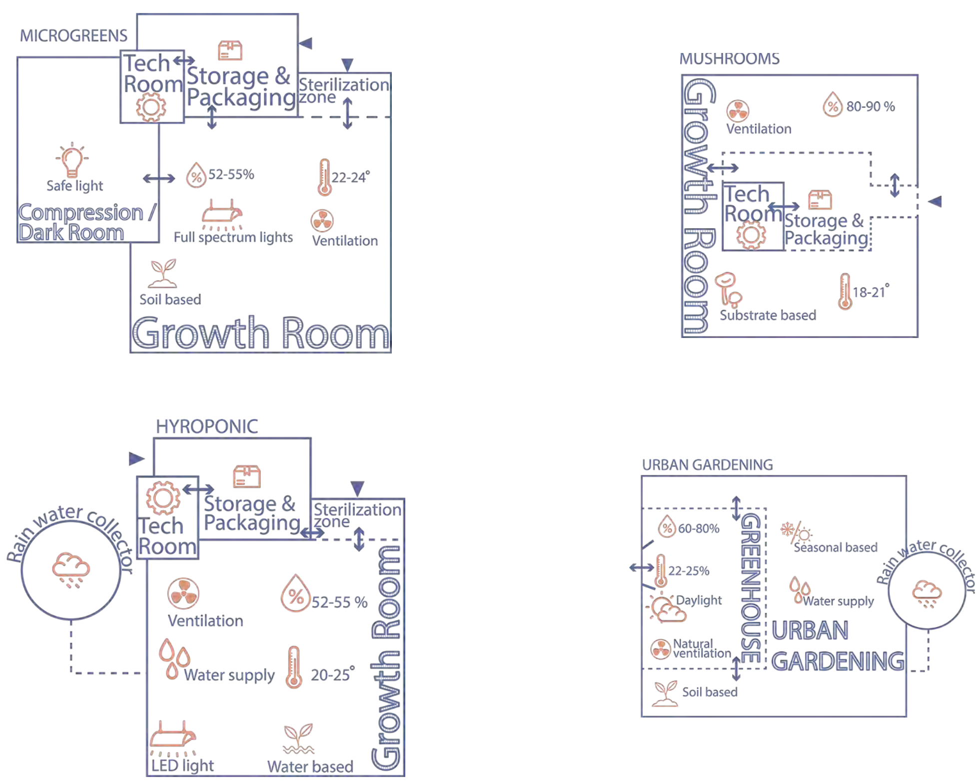
Illu. 41: Atmospheric section

INVESTIGATION:
THE TYPOLOGIES BIOTOPES

Synthesizing the previous users, site analysis & theory as well as inspiration from the related cases the different functions and activities of the typology has been chosen. In this thesis each function will constitute as a biotope, which per definition means.

Biotope definition: a usually small or well-defined area that is uniform in environmental conditions and in its distribution of animal and plant life. (https://www.dictionary.com/browse/biotope)

The program of the biotopes has been divided into different categories such as urban farming, education, and food literacy. As these will be integrated into the building their approximate sizes, usage and climatic conditions have been listed below. To create a better understanding of the atmosphere and connectivity of the different biotopes a conceptual section and organization has been created. together with a conceptual organization.



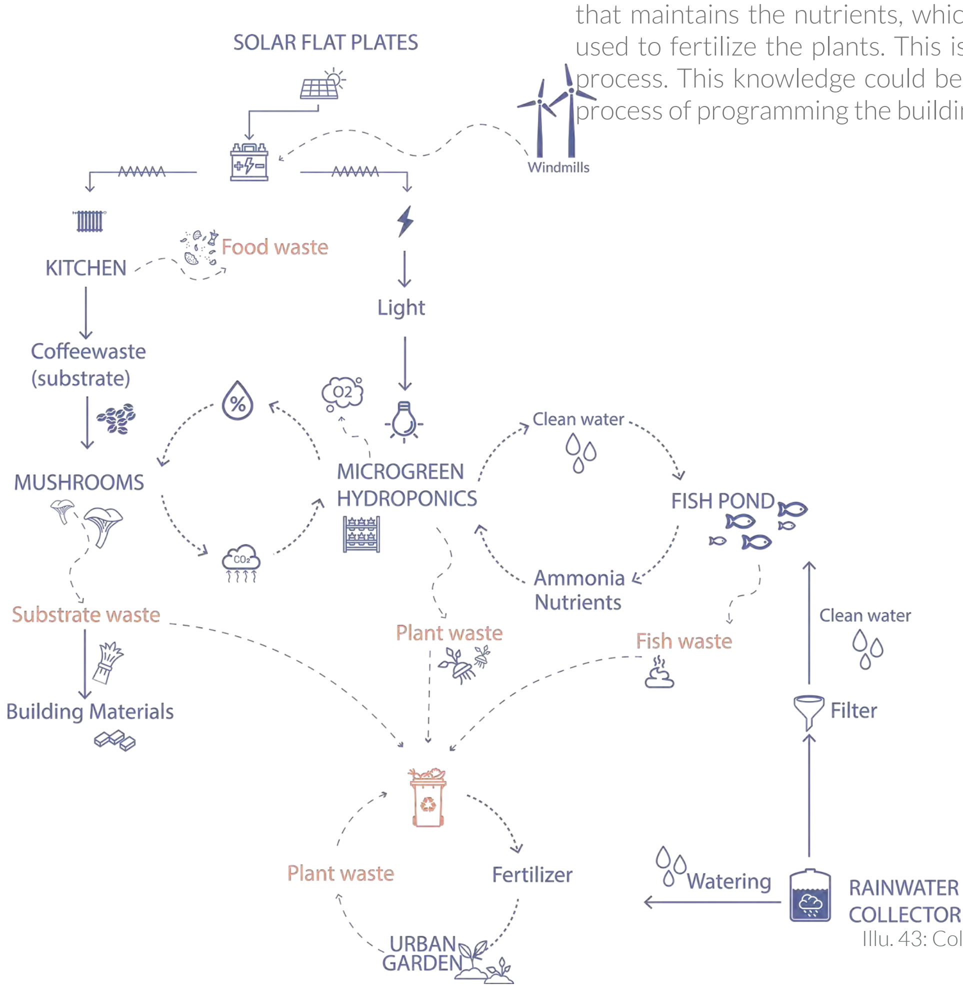
Illu. 42: Individual biotopes

INVESTIGATION:
AN ARTIFICIAL ECOSYSTEM

In continuation of the biotopes these create a form of symbiosis where they on a larger scale can benefit from each other creating a whole artificial ecosystem, which can represent the buildings technical engine, an ecosystem can be defined as.
A system, or a group of interconnected elements, formed by the interaction of a community of organisms with their environment (https://www.dictionary.com/browse/ecosystem)

The illustration suggests the way the ecosystem works, and as the building program will consume a lot of energy to provide for the cultivation methods, the building relies on external sustainable sources of energy to run. As an example, it could come from surplus energy from wind generators and district heating.

Furthermore, to enhance the life cycle of the ecosystem, biowaste from the different biotope processes will be gathered in a compost heap, that maintains the nutrients, which then can be used to fertilize the plants. This is a continuous process. This knowledge could be helpful in the process of programming the building.



Illu. 43: Collective ecosystem

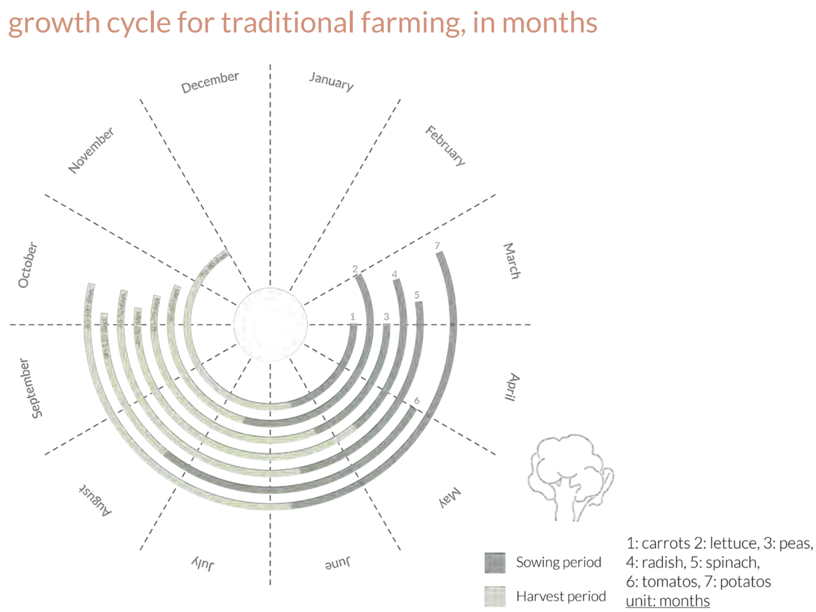
Growth Cycles for Plants and Spires

Based on the functions mentioned which will be incorporated into the design, different types of cultivation systems will be included. Therefore, it is necessary to create an understanding of what and how to design for these food systems. Firstly, it is important to understand the growth cycle of traditional agriculture and crops. The crops are seasonally based, only having one or two harvest periods during the year. This process is highly dependent on the seasons and the weather conditions. The weather conditions especially are an unpredictable factor influencing the success of the harvest.

In traditional agriculture the crops must grow to a mature stage before they are harvested. This process is significantly longer than reaching the desired stage for microgreens. For example, broccoli takes more than 50 days to grow to full maturity, while it only takes seven to 14 days to grow as microgreens.

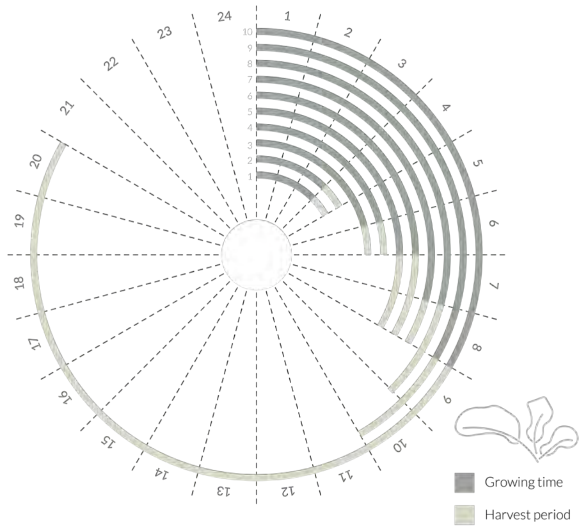
Using vertical farming in the form of mushroom, hydroponic, and microgreen farming, it is possible to extend the season and have multiple harvests each year, in some cases every two weeks. Microgreens do not need to grow to full size before harvest, cutting down the growth period substantially. Furthermore, the climatic conditions are highly controlled, leaving only a small percentage of lost crops.

The endless seasons and countless harvests during the year bring a great opportunity to incorporate an aspect of green in the building at any time of the year. Through an analysis of the different plants' growth cycles, the placement of them can insure the users´ experience.



Illu. 44: Growth cycle - traditional farming

growth cycle for hydroponic farming, in weeks



1: leetuce 2: radish, 3: cucumber, 4: kale, 5: squash,
6: tomato, 7: peas, 8: bell pepper, 9: carrot, 10: broccoli
unit: weeks

Illu. 45: Growth cycle - hydroponics

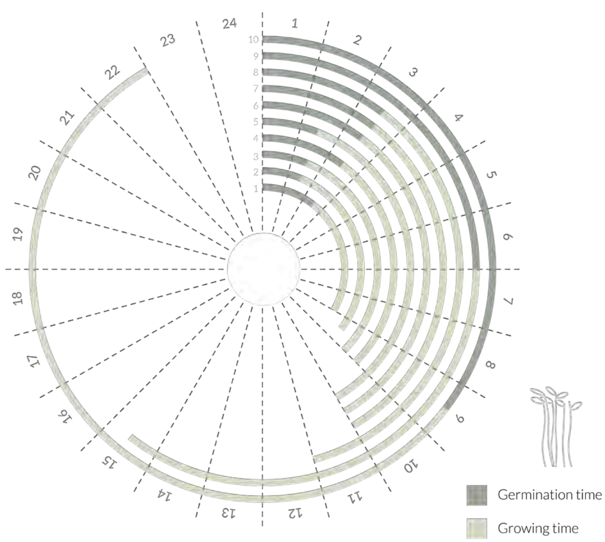
Hydroponic farming has the advantage of not being dependent on the weather and the seasons. With a highly controlled environment, the growth process is controlled minimizing the percentage of lost crops and extending the season to the full year. For example, lettuce only takes 20 to 30 days using hydroponic farming while it takes 50 to 60 days using traditional cultivation methods. With hydroponic farming it is possible to harvest 8-12 times during the year increasing the produce significantly.

It is important to place the different hydroponic systems strategically in relation to the species' growth cycle and needed environmental conditions.

	substrate	
mushroom	bags	logs
Oyster	3-5 weeks	6 months
Shiitake		6 months
Wine cap	4-6 weeks	
Pioppino	4-6 weeks	
Lion´s mane	4-6 weeks	1-2 years

Mushroom farming separates itself from the other plants and greens by its environmental needs and conditions. Furthermore, the mushrooms have very different growth cycles and lengths. The time depends especially on the substrate the mushroom grows on. For example, the oyster mushroom can be ready for harvest in three to five weeks when grown in a bag, but it can take more than six months on logs.

growth cycle for microgreens, in days



1: kale, 2: broccoli, 3: radish, 4: amaranth, 5: sunflower,
6: pea shoot, 7: beet, 8: carrot, 9: celery, 10: asparagous
unit: days

Microgreens have the shortest growth cycle, the shortest of seven to eight days. Most of the growth period is visible above the substrate making them suitable for installations.

Illu. 46: Growth cycle - microgreens

An investigation of micro greens farming growth process

With inspiration from company visit, gained knowledge of the different cultivation systems have been introduced in relation to this paragraph. Using the different cultivation methods both for their practical purposes but also as an integrated and visible part of the architecture.

A company visit provided a lot of inside knowledge of how this entire vertical system is built and what climatic conditions the owner uses to produce the amount microgreens which he needs. With only a space of approximately 27 square meters with shelving system taking up most of the space, aside from a preparation area, he provides 46 kg microgreens every ten days.
The shelves are set up with artificial lights and smaller fans on each system.

A humidifier secures the optimal temperature in the room for the sprouts to grow. In the back of the room is the compression/ dark area which provides more strength, so the seeds sprout quicker and longer when placed under the lights.

As a continuation of learning and gaining knowledge of how these farms and the produce could be integrated as part of the building, a physical study of microgreens growth began. However, it is important to state that this experiment was done with the use of natural lighting and without controlled humidity or temperature.

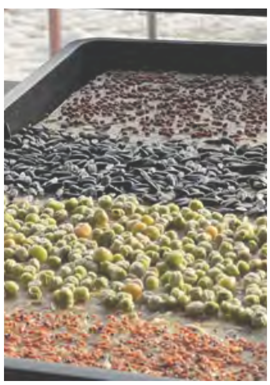
Illu. 47: Layout of a smaller microgreen production

Growing Micro greens:

1. Trays 30x60
2. Hemp sheets or other substrates like soil or coco quire.

*Water could also be used as the main soil. this is the hydroponic way of growing microgreens or other green produce.

3. Ventilation
4. Sun or artificial lights
5. Water
6. Seeds of different kinds



Synthesizing the gained knowledge in correlation with the company visit to spireli, this experiment was a success in terms of how easy it is to grow microgreens. Furthermore, it was evident that people were curious about the process, but also found the final product of spires delicious. The trays also stayed fresh for many days.

How to:

Soak the seeds in water, depending on the sort of seed, different soaking times are necessary. For peas: 12 hours. Place the soil or sheets of hemp in the tray and scatter the soaked seeds onto, water the tray and place them by a window, preferably towards the south.

Use the fan to ventilate the micro greens to prevent emerging mold. Water daily and see the progression of the growth every day. Enjoy the freshly grown micro spires on Danish smorrebrod or in salads, or just use as garish on a dish.

Illu. 48: Growing microgreens

This observation underlines a certainty of how this could be integrated into the new building, as it can enhance the curiosity, the hands-on activity and the atmosphere of a space in terms of smell, taste and the visual pleasure of the greens. The quick growth cycle provides a lively and natural change in atmosphere which can augment the experience for the users and show the process.

An investigation of the mushroom growth process

Parallel to gathering knowledge and research about the different cultivation process and growth cycles, a physical study of mushroom farming was done to investigate how easy and quick certain mushroom species can grow just from a plastic bag.

The experiment consisted of a bag of mycelium with hay as the main substrate, for the mushroom to grow on. Over a period of four weeks, the mycelium sprouted into large edible grey oyster hats. The diagram shows the difference in its appearance during that time lapped.

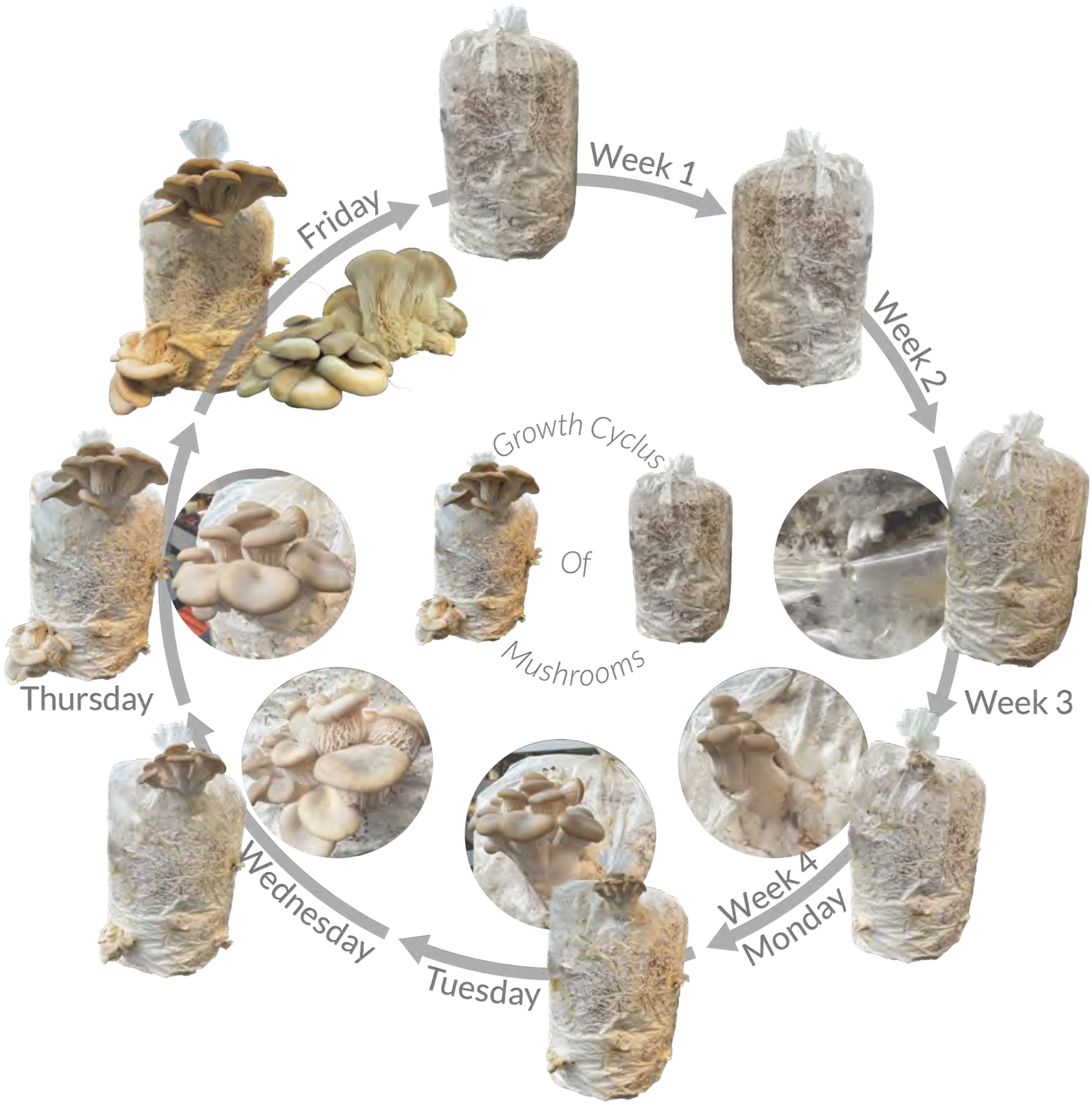
This sort of ethnographic investigation provided a lot of personal experience and knowledge of how quick the mushroom growing process is, as well as what needs they have in terms of climatic conditions to grow.

Illu. 49: Harvested Mushrooms

The experiment provided new knowledge about how its surroundings had an impact on the size of the mushrooms and which holes the mushrooms sprouted from first. As an example, the bag was placed in the group room up against a concrete column and out towards the atrium. The concrete has a high thermal mass, and this influenced the sprouting time and size of the mushrooms which were placed near that, whereas the other mushrooms away from the column grew big over the time period.

Furthermore, as the bag was placed in the group room, it was met by a lot of different expressions. Many people from other groups found the bag a bit disgusting as it appeared moldy, this was their first impression, but further in the process when the bag began to sprout mushrooms people began to see the fascination of growing mushrooms. This sort of observation was also very useful for the experiment as it could be used as a factor for designing the mushroom growth room in terms of visibility.

Lastly, the experiment also contributed to a social and fun experiment, as the next step of the experiment consisted of harvesting the produce and creating a meal from it.



Illu. 50: Growth cycle - mushrooms

From soil to table:

Creamy Mushroom Toast and Pasta

As part of the experiment of mushroom production the experiment reached the table. After harvesting the oyster hats from the mycelium bags the produce was weighted which resulted in 671 grams of mushrooms on the first harvest from the bag.
The mushrooms would be the main character in a dish consisting of making a creamy mushroom sauce which could be used on toast or in a pasta dish. It only took 20 min preparation time and a few extra ingredients until the dish is complete.

1. Grey oyster hats
2. Red onion and garlic
3. Lemon
4. Heavy cream
5. Butter
6. Salt and pepper for taste

Slice the mushrooms into bitable pieces, cut the onion and the garlic finely. Then on a pan with some butter, fry the onion and garlic until they turn clear, add the mushrooms, and let them fry until soft and golden, then add cream and salt, pepper, and lemon to taste. Meanwhile cook the pasta or toast slices of bread.

When the mushroom sauce has turned into a creamy consistency mix with the pasta or pour on top off the bread. Garnish with a bit of parmesan and parsley

Illu. 51: Mushroom recipe

Conslusion:

The recipe was simple and tasteful, the process of observing the mushroom from bag to product, to table was educative. As a further investigation this thesis aims to use mycelium spores and different types of substrate such as hay, experiment with creating biobased building materials.

From Table to Waste
Mycelium Experiment

The facilities of the building aspire to recirculate waste from its food production by upcycling the biowaste into building materials and to utilize it as compost. As part of this aspiration and with inspiration from the growing pavilion, an exploration of how to create mycelium as a biomaterial was made.

Mycelium consists of the root part of the fungi; the mycelium absorbs and breaks down organic matter, like leftovers from agricultural such as hay, or other wastes like sawdust or coffee grounds. The spores use these nutrients which then create a sturdy glue-like substance (Siim Karro and Killu Leet, 2022).
As stated from the case study of the living pavilion the material has great characteristics of being both fire resistant, water repellent, insulation value as of wood fiber, and it is biodegradable so it can be thrown out without any harm.

1. Mycelium Spores
   (Tinder fungus, Oyster hats)
2. Substrate
   (Hay, Hemp, or Coffee grounds)
3. Disinfection Area
4. Water
5. Trays

First step is to disinfect the area and the trays as this is very vital for the experiment's outcome. Hereafter mix the different substrates with the mycelium spores in disinfected bags or trays, close them and let it incubate to ferment for approximately 2 weeks. In this time cap the spores will break down the substrate and create its glue-like structure, making a sturdy form, which then can be used as interior cladding or wall insulation.

Illu. 52: Mycelium experiment

Conclusion:

By introducing materials such as Mycelium panels in the building underlines the story of utilizing the potentials of leftovers, which relates to the new typology's food facilities and production. The panels are aspired to be used as cladding for mushroom production to provide tactility in the space and as acoustic panels in other areas of the building.
The experiment constitutes to an initial trail of creating bricks without the use of an oven, dry time etc. In the limited extent of the experiment two different substrates of coffee ground waste and shredded straw was testes together with oyster hat spores. The tray with straw shreds created a brick-like form, but the coffee grounds only created a membrane on the top.

Synthesizing the experiment provided knowledge about the process, which will be used in the further design development of the building like how the mycelium in an aesthetic way could be integrated in correlation with other materials.

Vision

Grobunden will be the first of its kind, embracing a new building typology, where breaking with traditional cultivational methods in a new forward-thinking narrative will serve an environmentally and socially purpose shaped through its architecture.

A food literacy and holistic approach of re-learning about how we can grow, harvest, prepare and cook fresh produce creates the foundation of the building. Through its program, it will create an interplay of culture, nature and technology and let visitors participate in cooking workshop and talks concerning food themes in the framework of new cultivational methods, where they can observe the growth of their produce and buy these directly from the smaller food hubs scattered around the building.

Considering the current function of the site the establishment of Grobunden will transform the parking area into a new climate-friendly parking area for electric vehicle and act as an **urban catalyst** and cultural node concerning food and urban cultivation placed as a transition between the new and old development of Aalborg.

The architecture will constitute a new public space where the built supports its **typology as an urban cultivation center,** supporting its green biotopes and its **artificial ecosystem** which will be an integrated and translated part of the new building. Through its ecosystem, it creates a symbiotic strategy which reduces carbon emissions and food shortages and in addition provides significant environmental and social benefits.

Site “as is”

Illu. 53: Site “as is”

Site “to be”

Illu. 54: Site “to be”

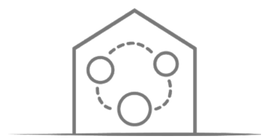
Design Thematics

Synthesizing theory, analysis and early investigations, different design thematics have occurred as questions raised throughout the analytical part of the process. These have been divided into four main thematics which then have following principles which will delimitate the future design process of the thesis. The defined thematics has been culminating into the following:

Urban Catalyst

Acknowledge the built environment but also promote to a change.

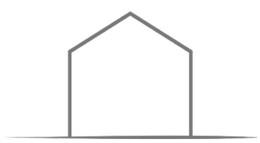
Act as a link both physically and socially between the old and the new Aalborg



The ecosystem

Integrating various biotopes and related functions to activate the use of the building.

Programming to enhance the symbioses between the biotopes and food literacy.



The architecture

Expressing the typology through a sustainable development

Enhancing spaces and atmosphere through the coherence of tectonics and materials.

The food literacy

Educating users about the food produce, infrastructure, and its potential.

Including social activities and interactions throughout the building.

Illu. 55: Diagrams of design thematics


04

DESIGN PROCESS

The following chapter presents highlighted parts of the design process, which have been made in an iterative process, underlining its nonlinear structure. Through a selection of explorations, the design process has evolved through a mixture of both analogue and digital methods and tools and with traditional architectural methods of sections, elevations, plans etc. which have had a significant impact on the decision making that then has culminated into the final design proposal of this thesis.

Illu. 56: Microgreens - pea sprouts growing

Form Follows Function

Placement of Volume

Building Envelope
Relation to Surroundings
Scale
Flow

The design process was initiated through a volume study which was created based on the presented room program of the building. The aim of using the room program was to create a foundation of comparison of approximately 6000 m^2 and to explore the possibilities and challenges of the different volumes. Various volumetric forms were investigated, where three concepts were analyzed further: Plaza, Central and Compact.
The different volumes were evaluated on their qualities of considering the surrounding relations, building envelope, scale in height and lastly flow possibilities and moreover on how the overall form supports the typology of being an urban cultivation center.

The first volume proposal evaluated was The Plaza concept, which created a form that stretches out on the entire parking area. It consists of th stories towards the west creating a higher gable wall which adapts to the opposite building complex height. Though the scale towards the west adjusts to its surroundings, the rest of the form becomes exceptionally large in both its form and envelope which causes the building to be less notable. In continuation, the flow around the building would preferably be inside creating a plaza or square as the form takes up all the space on the level. In addition, the flatness of the form does not vindicate the typologies cultivational functions and characteristics of vertical farming.

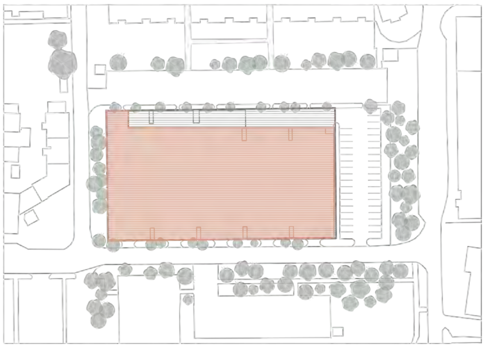
Secondly, The Central volumetric form, was placed in the center of the parking space and in more compact form which created three levels to support the 6000 m^2. The form is much denser which supports the vertical aspect of the typology and enhances the passive means of minimizing the building envelope, and therefore minimizing the risk of thermal bridges.

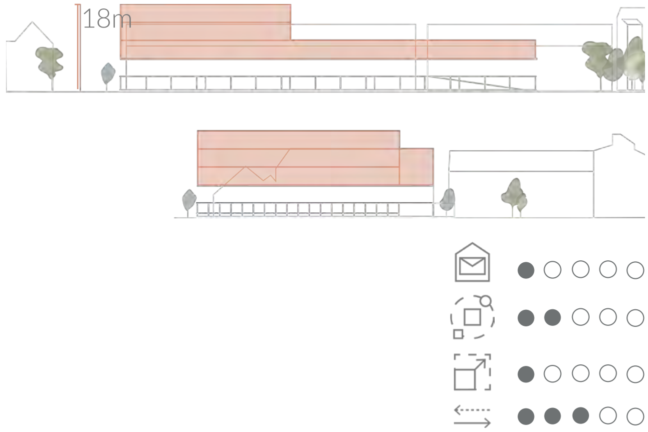
The placement opens the possibility of creating different spaces all around the building, supporting a more dynamic flow. Though the area towards the north creates an unattractive outdoor regarding the microclimate analysis, therefore this should be considered when programming the spaces.

The height of the building justifies its surroundings as the form is placed further from its surroundings and would therefore not create shadows on the nearby buildings. The southern façade invites for integrating a rooftop garden. In addition to the height and the overall form the volume creates a clear contrast between the new typology and the parking area which supports the concept of taking monofunctional urban spaces and transforming them into multifunctional.

The compact volume, focused on utilizing the west of the parking area, this created a much more square and compact form which likewise the central form, supported the vertical aspect as well as minimizing the building envelope. The placement towards the west of the site creates a large area on the deck, which could constitute to programmed outdoor areas, though these would be affected by shadows from the building in the afternoon. Furthermore, the form's height adapts to the opposite buildings but would with its form spoil the morning sun for the residents.

In continuation of the evaluation of the different forms follows the typologies' function and programing, therefore a parallel study was made to explore how these different volumes could be programmed.

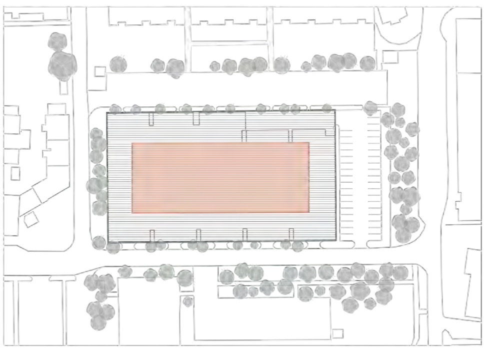


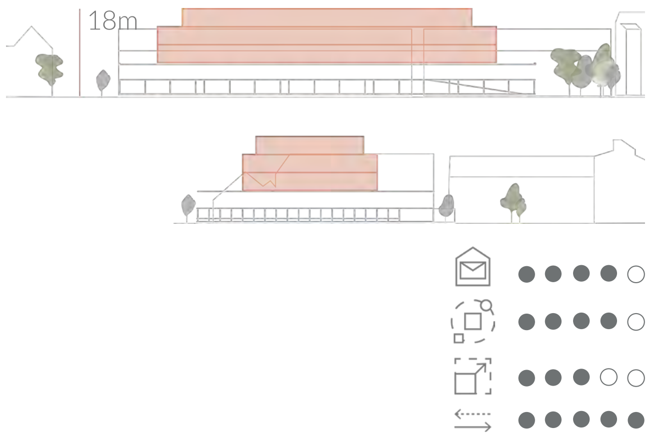


The Plaza

Footprint: 4.230m^2

3 stories heigh ceiling height 4 m

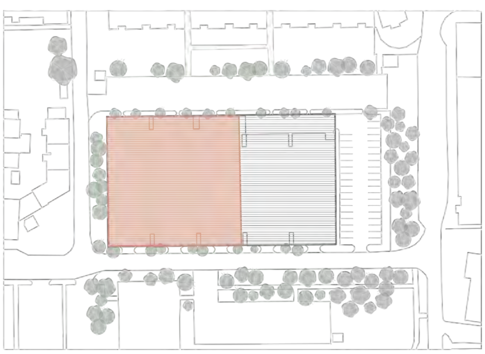


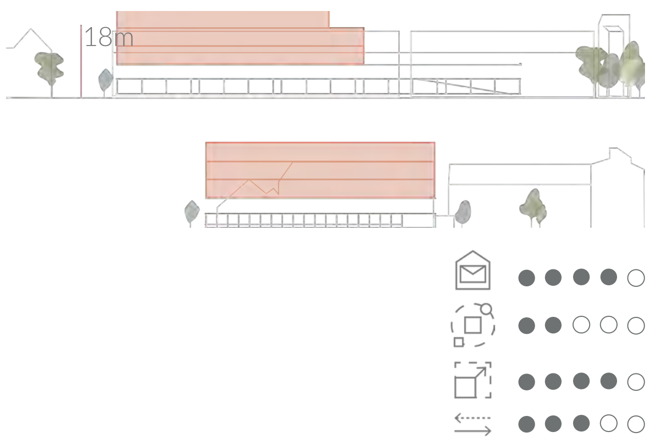


Central

Footprint: 2.268m^2

3 stories heigh ceiling height 4 m





Compact

Footprint: 2.877m^2

3 stories heigh ceiling height 4 m

Illu. 57: Placement of volumes

Illu. 58: Sections of volumes

Spatiality

Circulation

Practicality

Relation

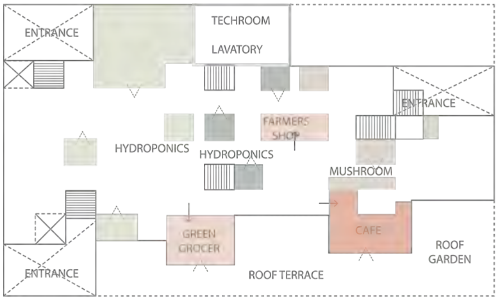
Programmatic organization

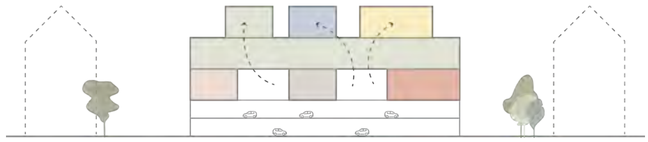
In continuation of the volume study and based on the room program, a parallel investigation of the programmatic organization was made to explore the interplay between form and function. The organization were evaluated based on their relation to each other, circulation around the building, spatiality between the placement of functions and lastly the practicality of production.

The first organization came from **The Plaza form** and having a volume with a footprint of 4230 m^2, here the functions were spread out to follow the form which created a plaza- like layout with large unprogrammed space in between the functions. The focus of this organization was to create a full private service and administration layer. This organization created a strict division between the public functions and the private, which enhanced the practical aspect, but also separated the relation to the social functions on the third floor (appendix 1). The main entrees of the building were placed with the intention of creating a flow through the building and enhancing the movement by placing the more public function down on the first floor and the more educational and food literacy further up in the building.

Secondly **The Central form** created a more interactive layout, where the focus was to enhance the food literacy and create a more delicate balance between the food production and the users' interactions with the vertical farms. This was done by mixing the placement of the different workshops and food producing, which enhanced the vertical movement in the building, forcing the visitors of the center to explore the other levels with visual contact into the hydroponics farms. Though this created some practical problematics with the relation of the farms and their prepping areas. The northly placement of the service functions goes for all three plan compositions, as it's more practical in regard to having a service elevator where there is street space for a truck to deliver articles and in regard to daylight and workspace. Though for this concept it also emphasizes a back side of the building which will be problematic to program. Otherwise, the flow around the building invites for integrating different food literacy functions like urban farming, community gardens and outdoor spaces for the café.

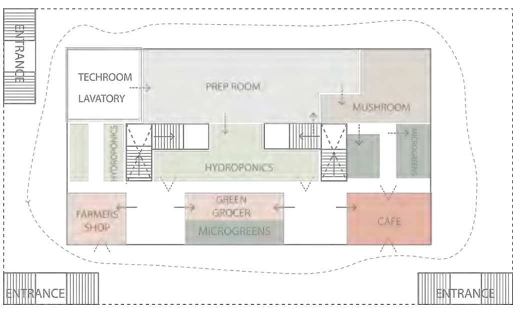
Continuously **The Compact form** was assessed with only one main entrance which emphasized the circulation up into the building creating an atrium. This provided the building with a more public and inviting atmosphere. The placement of the form created a large outdoor area towards the east of the site which could be programmed, though the space would experience problems with being overshadowed by the building mass in the afternoon hours. The relation between food production and their related service was optimized. Furthermore, the placement of the restaurant and the greenhouse was with the inspiration of Østergro intentionally placed on the top floor to create a more intimate and private atmosphere. Compared to the plaza concept this concept was too compact in its plan composition, minimizing space for food knowledge and literacy inside the building.

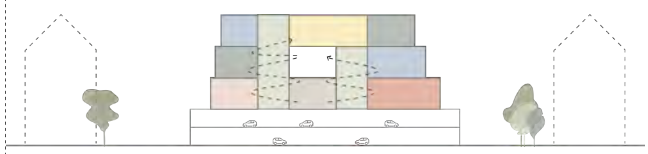




Spatiality ● ● ● ● ●
Circulation ● ● ● ○ ○
Practicality ● ● ● ● ●
Relation ● ○ ○ ○ ○

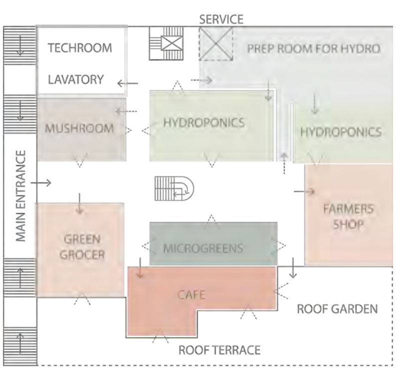
The Plaza

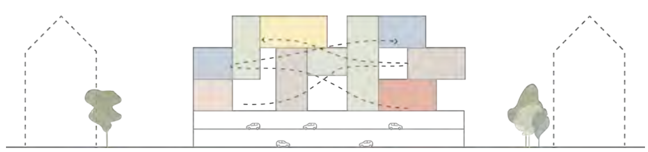




Spatiality ● ● ● ○ ○
Circulation ● ● ● ○ ○
Practicality ● ● ○ ○ ○
Relation ● ● ○ ○ ○

The Central





Spatiality ● ○ ○ ○ ○
Circulation ● ● ● ● ○
Practicality ● ● ● ○ ○
Relation ● ● ● ● ○

The Compact

Illu. 59: Organization of volumes

Illu. 60: Vertical Organization of Volumes

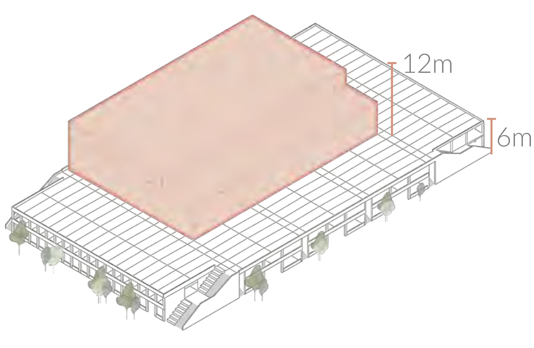
The Form and Function of an Urban Cultivation Center

Summarizing the two prior studies together with the knowledge gained from the initial investigations culminated into an altered design concept. The central concept had the strongest potential in its form but had problematics regarding the outdoor area it created. Therefore, it was chosen to place the volume towards the north, as this solution closed off the circulation around the building and instead created a well-defined outdoor area to the functions inside and could be programmed to fit the climatic conditions. Moreover, it serves the practical purpose of creating a service backside, for delivery.

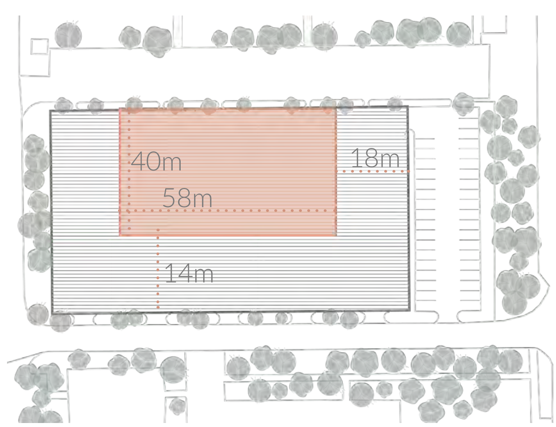
The form and orientation constitute two of the most important passive design strategies in terms of reducing energy consumption and improving thermal comfort. Therefore, the shape and compactness of the form minimizes the buildings envelope. And additionally, from the earlier structural investigation the form is strategically placed to be situated between the existing light shaft, as they will be used to support the building by integrating new columns.

The programmatic design process provided knowledge about the interplay of form and function which concluded in creating a hybrid of the different plans, utilizing the qualities from the different concepts which created the combined solution. Creating one main entrance enhances the public atmosphere and invites the visitors in. the mixed organizations provide a balance between the food production and the food literacy, the proposed layout worked with the concept of having workshops in relation to each of the different cultivation programs. And with the atrium being a place where the functions could melt into each other and be a flexible space of knowledge, exhibitions, and social gathering. Furthermore, each cultivational function has its related prepping and service space, which creates the sanitary boundary from public.

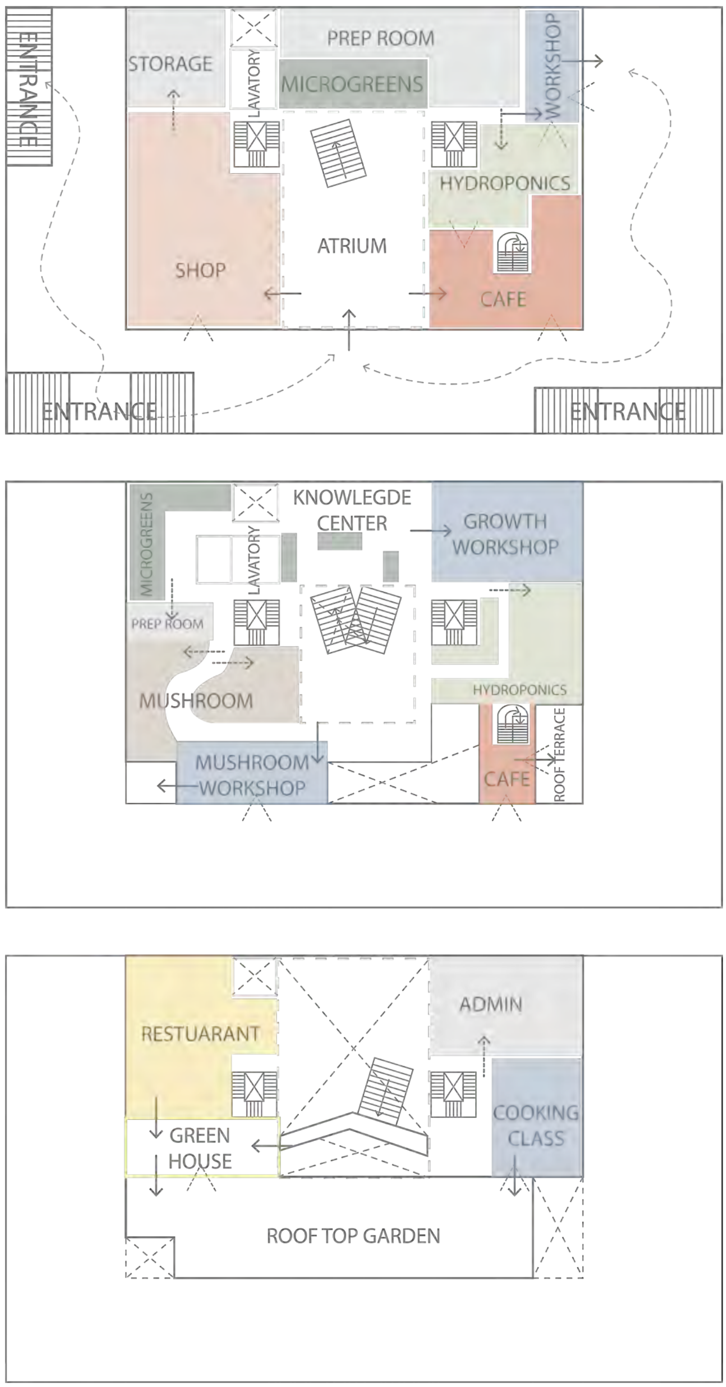
Conclusively the challenges of considering both parameters of food literacy and the practicalities of food production and how to create a balance between the two will be presented later in the process. Additionally, it is evident that there will be a lot of sun on the southern façade, which can cause high heat gains. Therefore, a solar radiation analysis will be conducted to investigate the possibilities of integrating passive means like solar shading regarding the façade and the fenestration.



Illu. 62: Isometric View of Form



Illu. 61: Placement of Form



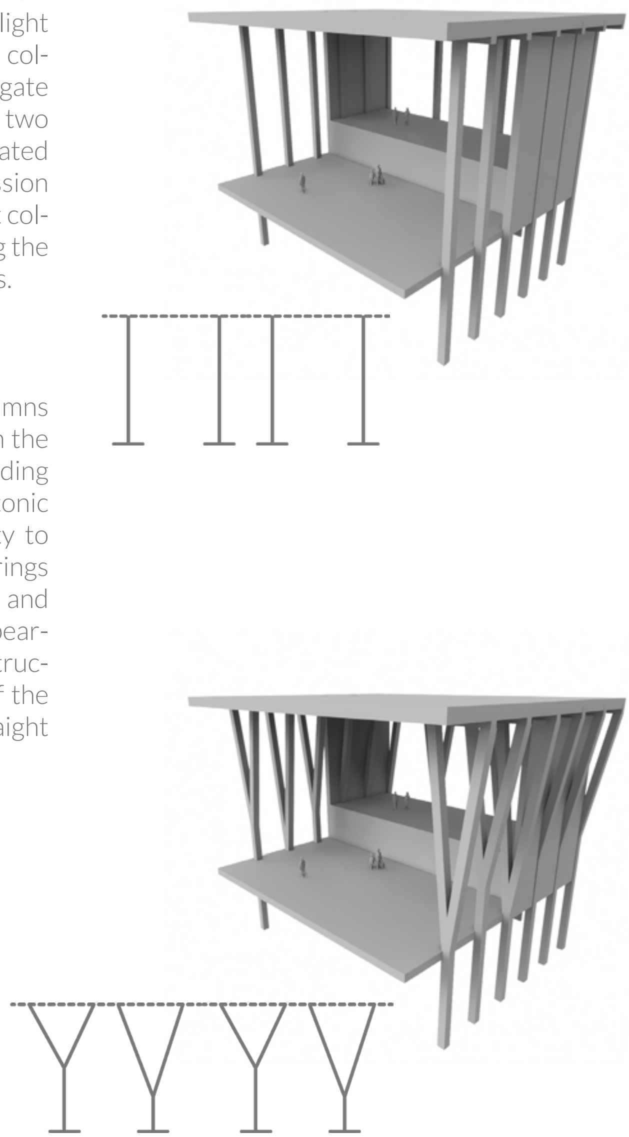
Illu. 63: Organization of Form

Tectonics Follows Form and Function

Structural Spatiality

The initial investigation on the structural system resulted in a system principle based on the existing parking structure while utilizing the light shafts for placement of the new structural columns with additional cores. To further investigate how to create and enhance atmospheres, two types of structural principles were investigated to enhance the internal and external expression of the building. The two shapes are a straight column and a Y-shaped column, both influencing the atmosphere and the perception of the spaces.

The simple frame structure with straight columns gives a flexibility for the programming within the building and brings a simplicity to the building facades. The Y-shaped columns bring a tectonic aspect to the spaces while bringing stability to the building using less struts. This shape brings some problematics in terms of fenestration and external and internal organization and appearance. Based on the intended programming, structural system, atmosphere, and perception of the spaces, the simple frame structure with straight columns were chosen.



Illu. 64: Structural and spactial investigation

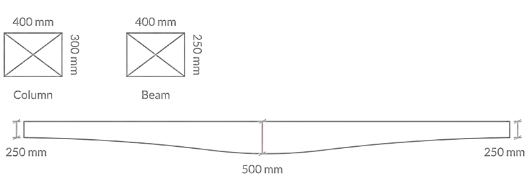
Structural Dimensions

Parallel with the other structural investigations, the dimensions of the structure were estimated. In order to choose the dimensions for the structural system, the existing parking structure is used to estimate the structural system of the new building. The parking structure is built to carry two concrete decks with cars.

The load from the cars is estimated to be 2.5 kN/m^2. The columns in the parking structure are placed every 2.5 meters and have the dimensions of 400x300 mm, while the beams spanning approximately 18 meters are 400 mm wide, and the height starts at 250 mm at the ends and ends at 500 mm at the center.

Existing car load
Car: 2800 kg x 4 = 11,200 kg
Area: 2.5 m x 18 m = 45 m^2
Load: 11,200 kg / 45 m^2 = 250 kg/m^2 => 2.5 kN/m^2

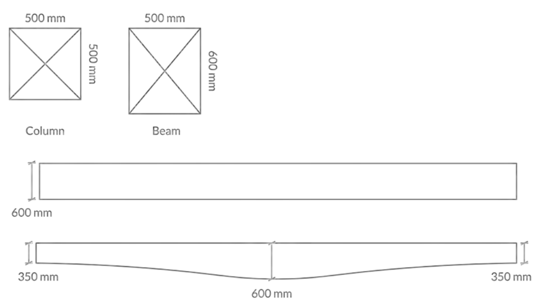
Production load
Hydroponics: 39 kg/m^2
5 layers of hydroponics:
5 x (2/3) x 39 kg/m^2 = 130 kg/m^2 => 1.3 kN/m^2
10 layers of hydroponics:
10 x (2/3) x 39 kg/m^2 = 260 kg/m^2 => 2.6 kN/m^2



Illu. 65: Existing beams

The heaviest production is hydroponic production with a weight of 39 kg/m_2 per layer. When stacking this production in ten layers and including an approximate distance between the shelves, the production has a weight of 260 kg/m^2. This is one of the largest loads in the building, and therefore one of the most critical points in the building.

The new structure will be of three stories compared to the two-story parking structure and will have to carry a larger load in parts of the building. Therefore, the construction components need to be larger than the existing ones. As an estimate the columns are dimensioned to be 500x500 mm and the beams to be 400x600 mm. 0 mm.



Illu. 66: new beams

Conclusively, the structural system with these dimensions would have to be concrete as the existing parking structure, but parallel to this investigation, possible structural materials and their GWP-impact were explored to see which material could be utilized.

Environmental Impact of the Structural System

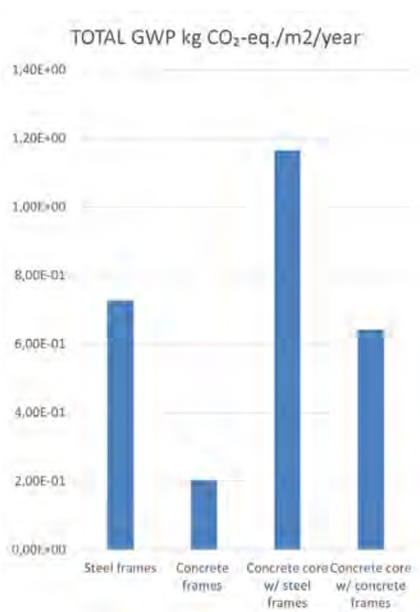
Alongside the initial investigation of the structural systems, estimates of the environmental impact were considered together with the overall structural dimension and how the system relates to the use within the building.

The structural materials of glue laminated timber, steel, and concrete all have different environmental impacts and structural abilities. Because the span between the columns is nearly 19 meters, construction of timber is not applicable for this project, as the height of the columns would be too much. Furthermore, timber construction is not suitable for the production of the different produce in the building because of the climatic conditions required in these production areas.

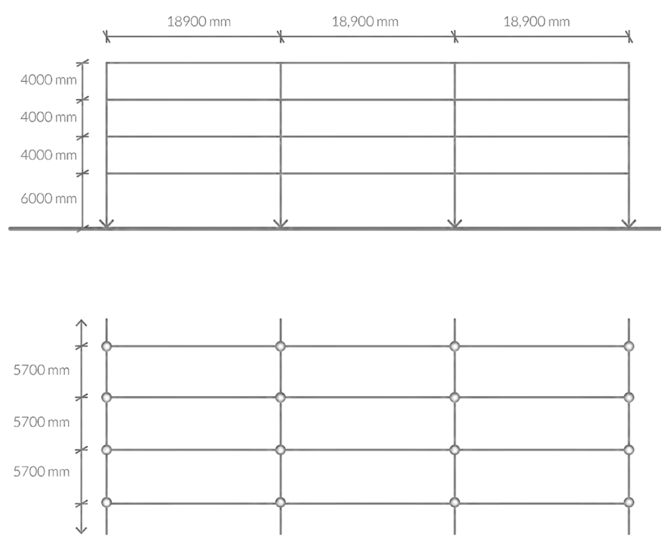
When looking at the last four structural combinations;

- steel columns and beams
- concrete columns and beams
- two concrete cores with steel columns and beams
- two concrete cores with concrete columns and beams

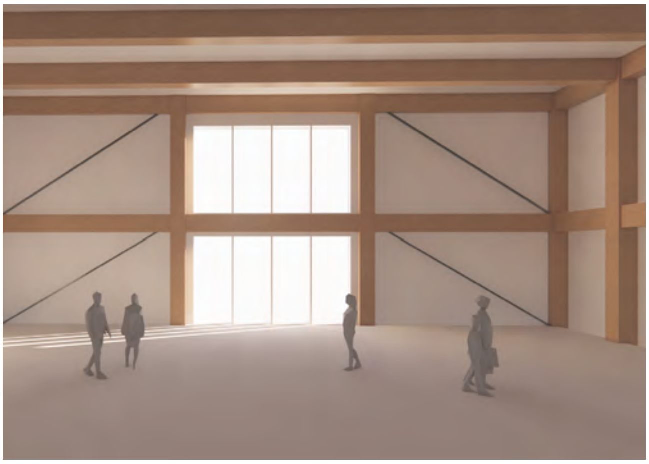
there is a difference in global warming potential (GWP) (appendix 8). An estimate of each structural system shows a lower potential for concrete columns and beams. Because of a need for vertical circulation from the lower parking level to the upper level of the new building, two cores are needed. Incorporating these two cores still leaves a lower GWP than the structural systems using steel.



Illu. 67: Structural systems' GWP



Illu. 68: Structural grid principle in section and plan



Illu. 69: Initial renders of material and atmosphere

The choice of structural system and its materials is based on these two investigations and evaluated on the environmental impact, structural dimensions, and the relation to the building typology and use. Therefore, a structural system of concrete cores with concrete columns and beams will benefit the project.

Conclusion in terms of structure and the large spans and functions concrete has been chosen. Through the integrated process of programming the building as well as making sure the structure follows the form of the building.

Internal Process

Plan Evolution

Through the process of organizing functions and creating spatial relations, different compositions were developed and changed to support the balance between food production and food literacy.

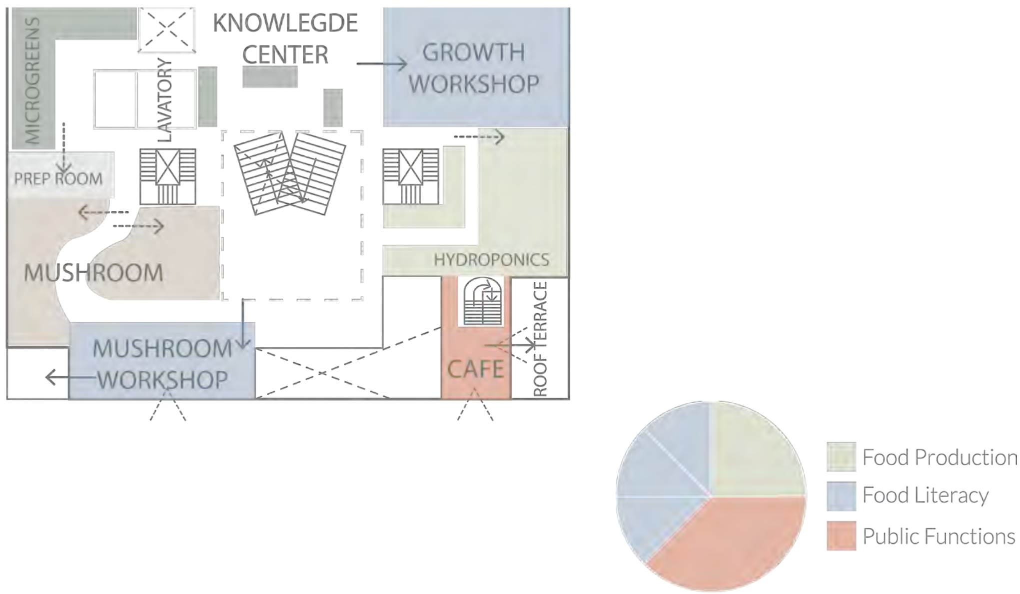
The organization of the first plan layout resulted in an internal mix of having a public first level and integrating both food produce and its related backstage. The atrium enhances the public atmosphere and acts as gatherings point for the surrounding functions as they could melt into the space. Lastly it will be the main space for daylight intake, which will be explored in the following process section.

Though the overall placement of the functions worked, there were still some problematics with the hierarchy between food productivity and food literacy. As seen on the conceptual pie diagram the percentage of the food production was lowest in the hierarchy which resulted in alterations of the programs sizes. Therefore, by minimizing the store area on the ground floor (appendix 1), more space for utilizing a double high room for vertical farming.

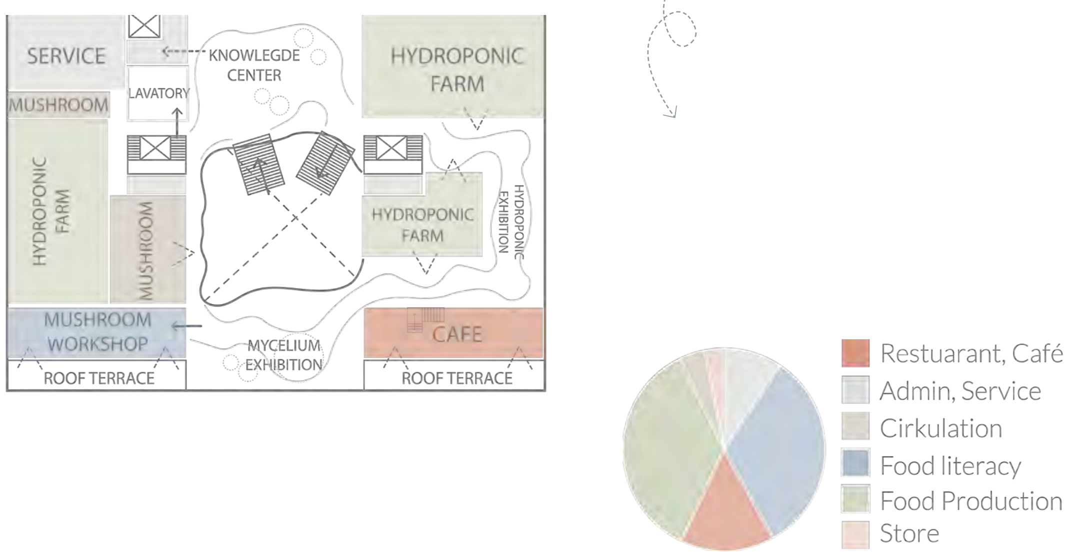
Furthermore, to enhance the atmosphere and by easily differentiating the spaces of the building resulted in working with the contrast of organic and geometric forms. Organic hallways and spaces were integrated in the more literacy- related functions, whereas more geometric forms were used for the more private and production-related spaces.

These curved forms along the atrium and around the spaces of the building enhances the inviting and public atmosphere while at the same time also acts as a guide, creating a sequence of movement throughout and changing from exposure to enclosure making the movement and flow more dynamic.

Moreover, different materiality will be investigated to support these spaces even more.



Illu. 70: Former plan layout floor level 2



Illu. 71: Updated plan layout floor level 2

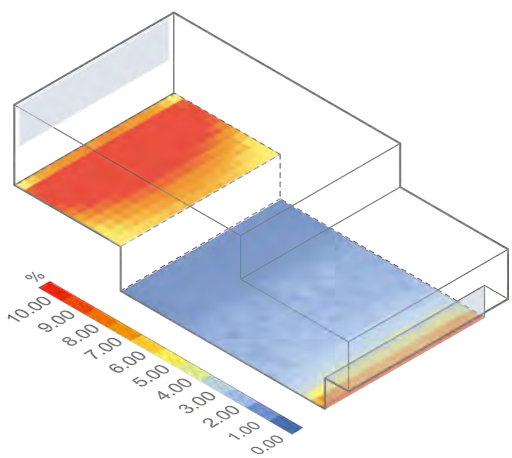
The Atrium

After defining the atrium in the building, further exploration of its appearance as a public and welcoming space was investigated, in correlation with calculations of a 24- average temperature calculation, month average calculation and daylight factor simulation.

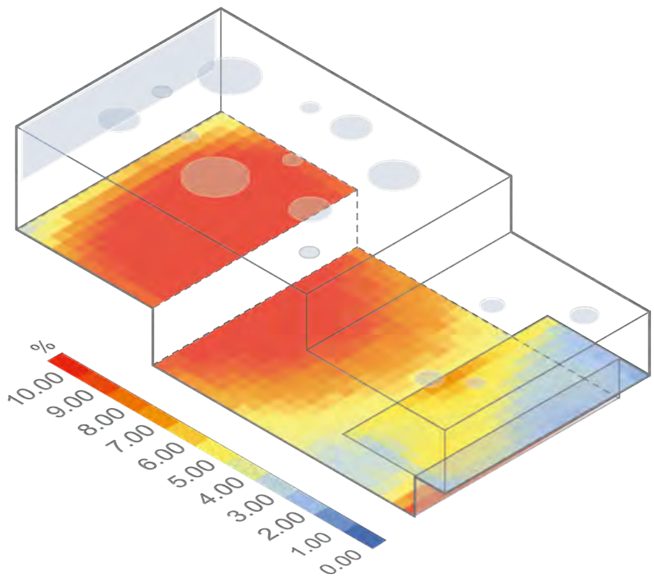
Different fenestration strategies were tested through a daylight factor simulation, to provide an understanding of the approximate amount of daylight to enter the building. The results of the daylight factor simulation provide information about the ratio of indoor daylight illuminance and provide an impression of how the daylight spreads across the defined space. A dynamic daylight simulation. The legend has been defined to express the percentage of daylight between 0-10.

The first simulation showed there would be less daylight in the atrium, therefore a skylight was integrated to drag more light into the building. This change provided light into the atrium and the form of the skylight enhanced aesthetics of the perceived daylight. In addition, the skylight could be utilized as a natural ventilation strategy for bouncy and cross ventilation.

Integrating a north-oriented window in the atrium supplies a higher daylight transmittance, giving that there is no direct sunlight and solar gains are therefore not a problem.



Illu. 72: Daylight factor simulation w/o skylights 10 pcs



Illu. 73: Daylight factor simulation w/ skylights 10 pcs

Illu. 74: Daylight factor - interior render

Thermal Comfort of The Atrium

The main entrance of the atrium is towards the south, and to enhance the public appearance, it was desire to open the façade. Therefore, parallel investigation of the indoor climate was conducted, to ensure a comfortable indoor climate.

This was tested through two simple calculation methods of a 24-hour average and monthly average temperature estimate together with the amount and type of fenestration.

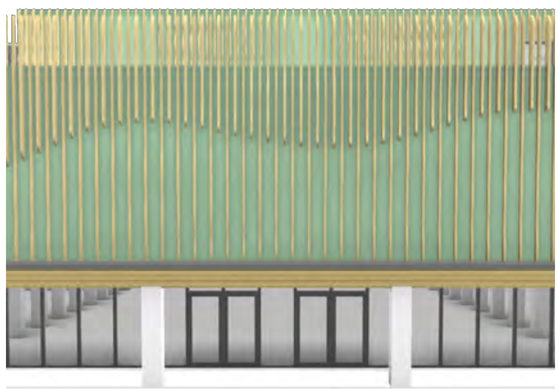
The calculation was first conducted with minimized fenestrations. The results showed that in July with ventilation at the same temperature as outside, the average 24-hour temperature was 24.6°C, and a maximum of 27.9°C (appendix 2). With ventilation of lower temperature, it was possible to bring down the maximum temperature to 24.4°C. With these results, another estimate was done to see the possibility of opening up the atrium more, increasing the window area. .

Values used Minimized Fenestration:

Window area: 177 m^2
G-value: 0.48
$F_{(afsk)}$: 0.9 (North) 0.4 (South)
$F_{(skyg)}$: 0.9 (North) 0.7 (South)
$F_{(glas)}$: 0.9

Ventilation
Air change: 1.3h^{-1}
Infiltration: 0.1h^{-1}

Internal Loads
People: 0/1525/4500 W (min./aveage/max)
Total: 100/2404/6600W (min./aveage/max)



Illu. 75: Minimal fenestration

Results :

Temperature / °C	Ventilation air same temperature as the outside air	Ventilation air constant temperature same as outside air temperature	Ventilation air with constant intake temperature two degrees lower than outside air
24-hour average	24.6	24.6	22.9
Variation	6.6	2.9	2.9
Max temperature	27.9	26.1	24.4

Values used for Open Facade:

Window area:	177 m²
G-value:	0.48
$F_{(afsk)}$:	0.9 (North) 0.4 (South)
$F_{(skyg)}$:	0.9 (North) 0.7 (South)
$F_{(glas)}$:	0.9
Ventilation	
Air change:	$1.3h^{-1}$
Infiltration:	$0.1h^{-1}$
Internal Loads	
People:	0/1525/4500 W (min./aveage/max)
Total:	100/2404/6600W (min./aveage/max)

Illu. 76: Open Facade

Results :

Temperature / °C	Ventilation air same temperature as the outside air	Ventilation air constant temperature same as outside air temperature	Ventilation air with constant intake temperature two degrees lower than outside air
24-hour average	25.1	25.1	23.4
Variation	7.1	3.5	3.5
Max temperature	28.6	26.8	25.2

The results for more open facades to the atrium showed that with ventilation and passive strategies, it is possible to open up the façade more than the previous example. The maximum temperatures are higher than the calculations with minimum fenestration, but the results are still within a reasonable range. With the use of ventilation and passive strategies such as cross ventilation and buoyancy it will be possible to keep the temperature within a feasible range.

These factors are important to acknowledge when considering the results. Conclusively by retracting the windows on the southern façade, it acts as a passive mean to provide solar shading. It is important to emphasize that the calculations only provide a glimpse into the temperatures, these results are only a guide for the atrium.

In addition to the 24-hour average temperature, monthly temperature calculations were conducted.

These calculations showed no need for cooling of the building, while the energy use on heating was 132 kWh/m²/year (appendix 3 and 4). When comparing this to the demands for the energy frame of 41.0 kWh/m²/year, the calculated value is exceeding the maximum.

This is notable, but the calculations do not take into account the passive strategies. In addition, this is only a calculation for the atrium, which is the most critical room both in regard to direct sun exposure and ceiling height. With a ceiling height of almost 12 meters, the atrium has a large volume to heat up.

Therefore, the outtakes from these calculations are that the atrium does not need cooling and there is a high demand for heating in the winter months, but with passive strategies, such as cross ventilation, thermal buoyancy and exterior shading it is possible to bring down the energy frame. Furthermore, in order to tell whether the building would meet the needs of the energy frame, all rooms were to be calculated.

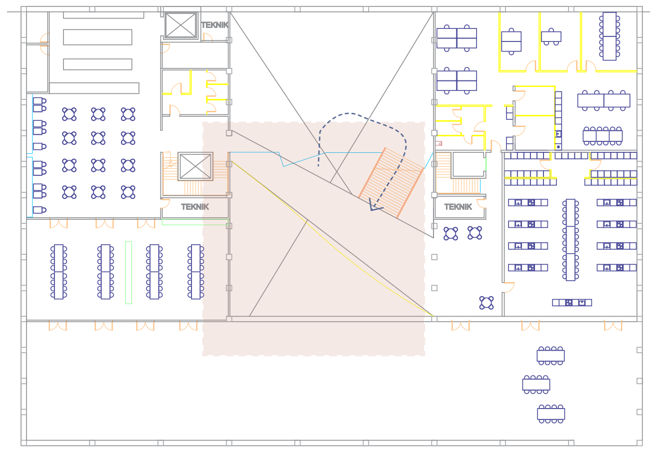
Internal Circulation

In the continues phase developing and detailing the plans and circulation in the building still had some problematics regarding the atrium's function as connecting element between the floors. The complexity of the atrium was therefore modelled in 3d, which gave a spatial visualization of the room. The interplay of working between 3d and 2d provides a better understanding of the space and its composition, where it in this instance seemed cluttered, which resulted in an internal reorganization.

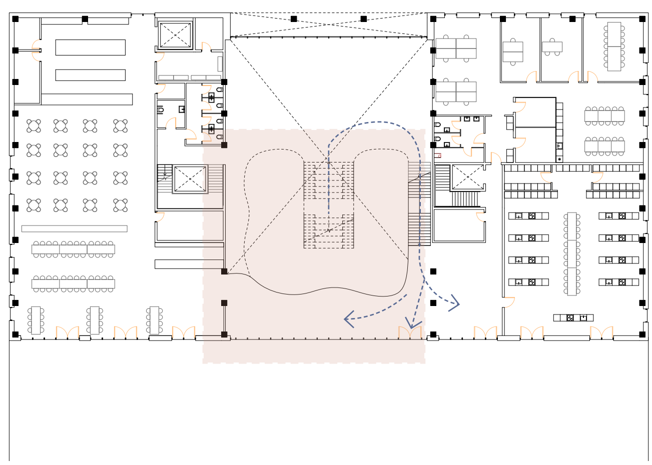
Previously the third level and its functions were connected by a passage bridge, here the arrival to the restaurant was through a smaller transition area between the public toilets and the core, this arrival appear more as a rear entrance. Furthermore, the functions seemed disconnected.

In addition to an alternation of the facades and the relocation of the greenhouse, provided much more space to the restaurant, and by adding a new platform along the southern wall provided a more symmetrical spatiality of the room. This resulted in a transformation of the circulation, where it was chosen to create a hierarchy where the stair and circulation became the defining element of the space.

Conclusively the new alteration of the internal circulation provided much more use of the atriums function as the main daylight intake as well as enhancing the public atmosphere through the open spatiality of the room. The new platform supports visual connectivity between floors.



Illu. 77: earlier plan layout of third floor and the atrium.



Illu. 78: altered plan layout of third floor and the atrium.

Illu. 79: 3D- models of the spatiality of the atrium

Atmospheres Within The Typology

In the process of developing the new typology, the question about how to articulate the atmosphere of the place accrued. Therefore, a tactile and materialistic process began by investigating how the different spaces could be enhanced through their materials, while at the meantime supporting the function.

Accumulating earlier analysis and experiments it was quickly noticed that there would be a lot of glass in the productions. Transparency provides a visual connection into the different food productions and the artificial lights interferes with the surrounding spaces, enhancing the curiosity to see inside. Furthermore, in the production areas, it was chosen to work with very subtle and sterile materials, because of its practicalities and the many regulations regarding food produce.

In addition to the changing expression of the greens, they provide a differentiated experience when the sprouts are fully sprung or harvested. Therefore, they can act as live material in public spaces. Through the earlier experiment it was also chosen to integrate mycelium panels in the exhibition and mushroom production area, as well as other places like the café.

Based on this knowledge gathered the further investigation of chosen materials for the interior began. here different material combinations were sampled to examine how these could provide a natural and organic appearance together with the futuristic and artificial characteristic of the urban cultivation methods. In relation to the exploration of materials a further analysis and calculation of various materials was undertaken regarding their life cycle and carbon footprint.

How can food produce be both practical, educational and atmospheric ?

Illu. 80: Material boards

Initial Environmental Impact of the Building

During the project development and early design phases life cycle assessment has been integrated to be part of the process to keep up with the current climatic impact of the design. This has been done through the acknowledgement of the building geometry and its construction. As decided earlier in the design process, the construction is a frame structure of reinforced concrete. LCA was part of the evaluation of the different structural systems and material options. The structural system is the first part of the LCA calculation for this project. The following collects a more holistic picture of the total global warming potential for the building, starting with standard building materials, which will be changed through the design process based on global warming potential, atmosphere, durability, texture, and other parameters important for each individual material and building component.

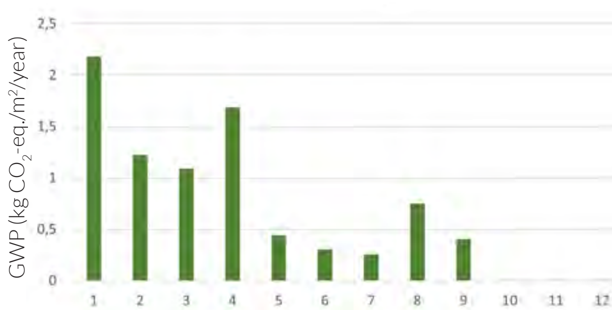
These LCA calculations include nine different categories: structural system, exterior walls, interior walls, floor slabs, floors, glass facades, roof, windows and doors, and foundations. The total global warming potential for the building based on these standard materials is 8.45 kg CO_2-eq./m^2/year. It is known that not all building components are included in these LCA calculations, which will be taken into account when comparing to the results to the allowed overall GWP of 12.0 CO_2-eq./m^2/year from the Danish Building Regulations. Therefore, the goal for these LCA calculations is to analyze the individual materials to improve the overall GWP for the building as well as the desired atmospheres and materiality within the building. This is done by analyzing each material or building category separately to establish their properties and potential in terms of their climatic impact and their appearance.

Initial Building Components

	Building component	Total w/o D
1	Structural system	2.180e+00
2	Floor slabs	1.226e+00
3	Heating, ventilation, and cooling	1.090e+00
4	Roof	1.685e+00
5	Interior walls	4.399e-01
6	Glass facades	3.023e-01
7	Windows and doors	2.558e-01
8	Exterior walls	7.495e-01
9	Floors	4.043e-01
10	Foundations	5.216e-02
11	Water	3.050e-02
12	Drain	3.000e-02
	Total	8.449e+00

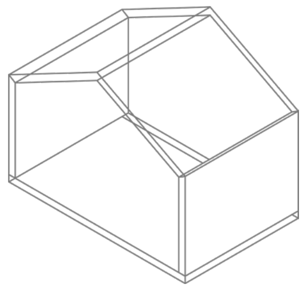
Unit: CO_2-eq./m^2/year

Initial Building Components, CO_2-eq./m^2/year (GWP)

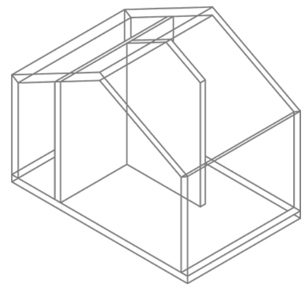


Illu. 81: GWP graph for inititial building

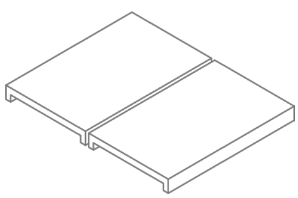
Structural System
- Concrete columns (500x500 mm)
- Concrete beams (400x600 mm)
- Concrete cores (load-bearing walls)



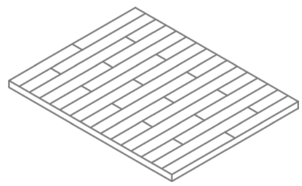
Exterior Walls
- Zink cladding
- Mineral wool insulation w/ wood rafters
- Gypsum boards with acrylic paint



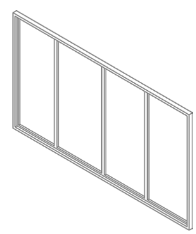
Interior Walls
- Wet room walls
- Light insulated walls
- Glass walls
- Light walls



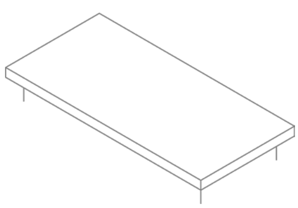
Floor Slabs
- Concrete slabs



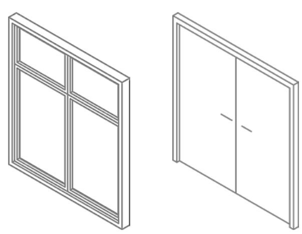
Floors
- Concrete polished floor finish



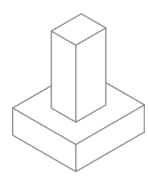
Glass Façades
- Glass facade panels
- Skylights



Roof
- Flat concrete insulated roof
- Gypsum ceiling panels w/ acrylic paint
- Light concrete ceiling panels

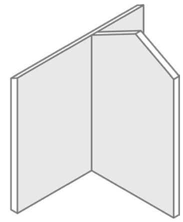


Windows and Doors
- Windows
- Fire doors
- Double doors
- Single doors
- Industrial doors



Foundations
- Concrete point foundation (400x1000x1000 mm)
- Core foundation (250 mm)

Illu. 82: LCA building components



Environmental Impact of Interior Wall Finishes

OSB Board

The 30 mm OSB boards made of thin strands of wood blended with resins and wax to improve the product's resistance to moisture, can bring texture to the walls and add to the atmosphere.

EDP operator:	EPD International AB
Registration number:	S-P-01850
EPD owner:	Norbord

Mycelium Panels

There is no EPD for mycelium, but the material is close to wood fibre, which this data is based on. The material is based on the waste products within the project typology from the mushroom production.

EDP operator:	EPD Norge
Registration number:	NERP-4037-3072-EN
EPD owner:	Hunton

Plywood

The plywood is similar to the OSB board and has the same thickness, but has a slightly lower GWP. The texture is more fine, and can bring a different look and atmosphere to the rooms.

EDP operator:	EPD Danmark
Registration number:	MD-20008-EN
EPD owner:	Træ.dk

Gypsum Board

The boards consists of an aerated gypsum core encased in and firmly bonded to strong paper liners. The gypsum core contains various additives. This is a more clean and simple wall finish.

EDP operator:	EPD International AB
Registration number:	S-P-00506
EPD owner:	British Gypsum

Illu. 83: Interior wall finishes

** GWP: CO_2-eq./m^2/year*

** Materials used in all LCA-investigations are shown in appendix 10 and all EPD's are listed in the EPD's reference list.*

Conclusion

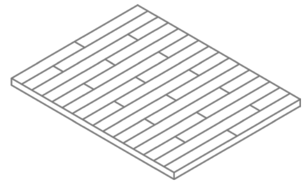
The four chosen materials all have their own qualities. Depending on the room's use, practicality and atmosphere wanted, the materials are chosen.

Mycelium is mostly for the exhibition of mushrooms and the cafe. This is to bring the whole story of the mushrooms and how it is possible to use different substrates such as used coffee beans when making mycelium panels. Together with the two wood materials, mycelium panels are biobased materials and can contribute to a warmer atmosphere compared to the gypsum boards.

GWP Change
Interior walls

Before:
4.40e-01 CO_2-eq./m^2/year
(-2.12e-01) CO_2-eq./m^2/year

After:
2.28e-01 CO_2-eq./m^2/year



Environmental Impact of Interior Floor Finishes

Concrete

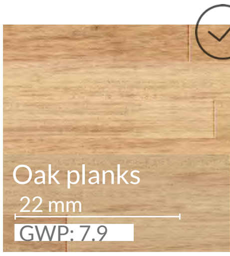
The 50 mm concrete layer is polished to bring out the texture and grains of the material. This is the thickest flooring material investigated, but it is sturdy and has a long service life.

EDP operator:	EPD Danmark
Registration number:	MD-22066-DA
EPD owner:	A/S Ikast Betonvarefabrik

Micro-cement

Micro-cement is seen as an alternative to the concrete flooring to bring down the GWP, while maintaining a the sturdiness to insure a surface applicable for production, storage, and technical rooms.

EDP operator:	EPD International
Registration number:	S-P-06174
EPD owner:	ISOMAT



Oak Flooring

The solid wood flooring can bring some warmth and texture to the spaces and enhancing another atmosphere than the other three materials.

EDP operator:	EPD Danmark
Registration number:	MD-19009-EN
EPD owner:	Junckers Industrier A/S

Linoleum

Linoleum is an alternative to both the concrete and micro-cement flooring. It is a practical flooring, but is not bringing the same aesthetic qualities as the other materials.

EDP operator:	UL Environment
Registration number:	12CA64879.101.1
EPD owner:	Forbo Flooring B.V.

Illu. 84: Interior floor finishes

** GWP: CO_2-eq./m²/year*

** Materials used in all LCA-investigations are shown in appendix 11 and all EPD's are listed in the EPD's reference list.*

Conclusion

The interior floor finish depends on the use within the rooms. Concrete, micro-cement, and linoleum are suitable for the production areas, the cores, and atrium. Oak planks are more suitable for classrooms, cafe, restaurant, exhibitions, and administration. When looking at the GWP, the concrete flooring used for the initial building is the largest, while it is also the thickest material. The alternative to this is the micro-cement which has a smaller thickness but still a strong surface, while having a smaller GWP compared to concrete. Linoleum is the material with the smallest thickness, while also having a low GWP, but does not score high on aesthetics. Oak planks have aesthetic qualities and add to the desired atmosphere.

The two main materials chosen for the project are micro-cement and oak planks.

GWP Change
Interior floors

Before:
4.04e-01 CO_2-eq./m²/year
(-3.04e-01) CO_2-eq./m²/year

After:
1.00e-01 CO_2-eq./m²/year

Environmental Impact of the Core Components of the Envelope

The core elements of the wall construction; insulation, frame, wind barrier, and vapor barrier, are analyzed and combined to construct the core layers of the exterior walls. With the load-bearing framing system of concrete, the envelope is a non-bearing construction.

Each component is analyzed individually based on LCA and other parameters important to each layer.

Lastly, the combined wall construction is constructed. Parallel to the wall construction, the interior and exterior cladding are evaluated, which influences the final wall construction.

During all LCA investigations, a number of materials are analyzed but only some are shown in the design process. The remaining materials and the more extended analyses are shown in the appendix (appendix 10-15).

Environmental Impact of Insulation Materials

Wood fiber

The Hunton wood fibre insulation plate is made of wood fibre combined with additives to add structure and fire-proofing. It is installed as panels.

EDP operator: EPD Norge
Registration number: NERP-2287-1041-NO
EPD owner: Hunton Fiber A/S

Mineral wool

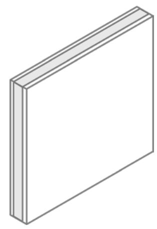
This insulation mainly consists of inert material, which is made of recycled material and mainly sand and dolomite. The remaining fraction is made of bio-based binder components, origin in plant starch.

EDP operator: EPD International AB
Registration number: S-P-04587
EPD owner: Knauf Insulation

Cellulose

The cellulose insulation is manufactured by recycled newspaper. The product is made from secondary-material waste paper, and is impregnated with mineral salts to protect it from fire.

EDP operator: Bau EPD GmbH
Registration number: EPD-ISOCELL-2014-1-GaBi
EPD owner: ISOCELL GmbH



Conclusion

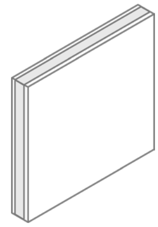
The insulation is evaluated on GWP and the thermal transmittance. An insulation such as straw was in the early investigations (appendix 12) deselected because of its high thermal transmittance. Others were deselected due to high GWP's. Lastly, the three insulations shown were picked to further compare. Mineral wool has the lowest thermal transmittance but because of its high GWP, it is not chosen as insulation.

Lastly, wood fiber and cellulose have the same thermal transmittance, but cellulose has the lowest GWP. Cellulose has a lifespan of 30 years, while wood fiber insulation lasts for 60 years. Therefore, wood fiber insulation is picked as the insulation.

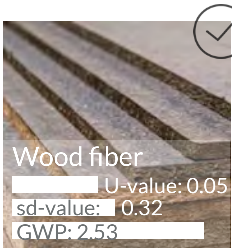
Illu. 85: Insulation materials

** U-value: W/(mK)*
** GWP: CO_2-eq./m^3/year*

** Materials used in all LCA-investigations are shown in appendix 12 and all EPD's are listed in the EPD's reference list.*



Environmental Impact of Wind and Vapor Barriers



Wood fiber wind barrier

This 25 mm Hunton wind barrier panel material protecting against cold, wind, and moisture. It is mainly made of wood fibre and impregnated to provide high performance and robustness.

EDP operator: EPD Norge
Registration number: NERP-4037-3072-EN
EPD owner: Hunton

Gypsum plasterboards wind barrier

This is a 9 mm glass fibre reinforced gypsum plasterboard with impregnated core. The main product component is stucco.

EDP operator: EPD Danmark
Registration number: MD-21091-EN
EPD owner: Knauf A/S

Conclusion

The choice of wind barrier does not have a significant influence on the overall GWP for the building, as some of the other materials. The choice for wind barrier is mainly based on the raw material used for the product, which is why the wood fiber wind barrier is chosen.

Furthermore, the wood fiber boards contribute to the overall U-value for wall.

RaniMoBar

The 0.2 mm thin plastic vapour barrier is a polyethylene based material with a high sd-value to protect the construction against moisture.

EDP operator: EPD Norge
Registration number: NERP-3293-19904-EN
EPD owner: Ab Rani Plast Oy

Gram vapour barrier

The vapour barrier is 0.2 mm thick and is an aging resistant and UV stabilized vapour barrier made of polyethylene with a slightly coloured blue colour.

EDP operator: EPD Norge
Registration number: NERP-341-230-NO
EPD owner: Tommen Gram Folie A/S

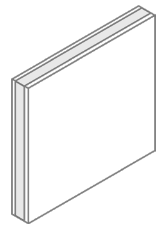
Conclusion

As the wind barrier, the vapor barrier has a small impact on the overall GWP, but the choice was made between two barriers, the RaniMoBar and the Gram vapor barrier. The RaniMoBar barrier was chosen because of a higher sd-value. Further, it has the lowest GWP of the two barriers.

** GWP: CO_2-eq./m^2/year*
** sd-value: m*

** Materials used in all LCA-investigations are shown in appendix 13 and all EPD's are listed in the EPD's reference list.*

Illu. 86: Wind and vapor barriers



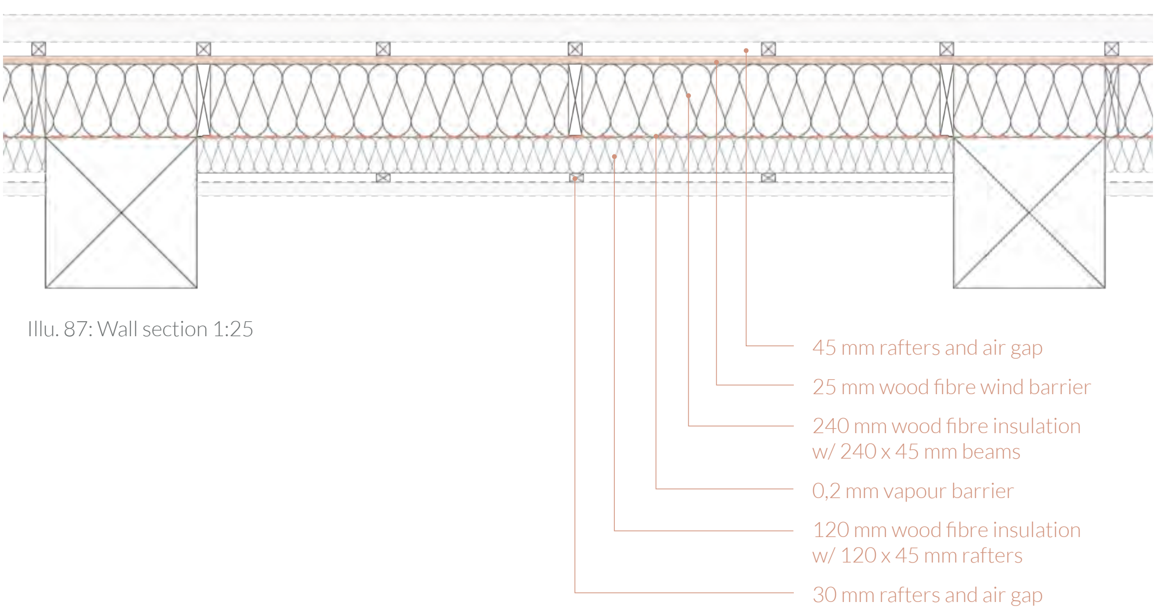
Construction of the Core Components of the Envelope

Parallel with the evaluation and investigation of the different components for the core elements of the wall construction, the overall wall construction was composed. Firstly, the core components of the wall were composed, while the exterior and interior cladding is investigated later in the process.

The wall construction is a simple frame system of wood rafters with wood fiber insulation. It is built around the load bearing system of the concrete columns, leaving the columns visible inside the building and making it possible to have windows on the outside of the columns.

Along with the environmental impact, the thermal conductivity for the construction is important. With the construction chosen, the thermal conductivity is 0.11 W/(m^{2}K), which comply with the standard requirements from the Danish Building Regulations of 0.3 W/(m^{2}K) for exterior walls (BR18, 2021).

Furthermore, the wall construction meets the requirements for the Danish 'low energy class' of 0.12 W/(m^{2}K) for facades (Rockwool, 2023). The façade meets this requirement and later the roof construction will be tested. With low thermal conductivity and a GWP brought down with 1.53e-01 CO_2-eq./m^2/year, the next step for the exterior wall construction is to investigate the choice of both the exterior cladding material and the interior wall finishes.



Illu. 87: Wall section 1:25

GWP Change
Exterior wall core

Before:
3.01e-01 CO_2-eq./m^2/year
(-1.53e-01) CO_2-eq./m^2/year

After:
1.49e-01 CO_2-eq./m^2/year

Illu. 88: Exploded wall diagram

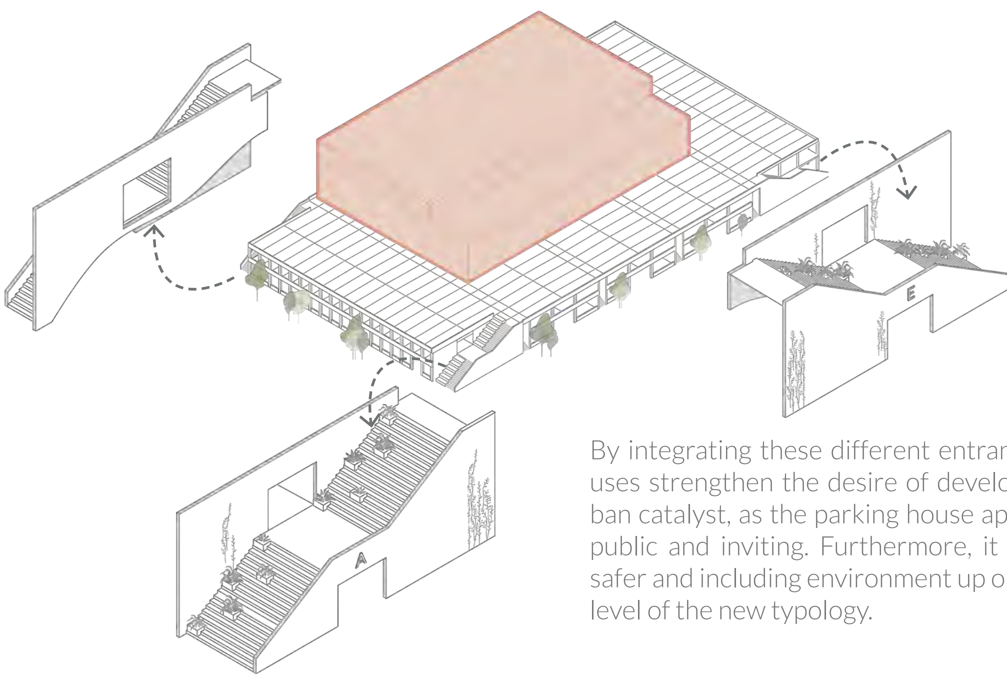
External Process

Outdoor Circulation and Arrivals

The chosen arrival points consisted of having three entrances up to the new typology. These were strategically placed based on the pedestrian's flow and on the previous initial investigation (page 56).

Integrating the new arrival points meant interfering with the outskirts of the parking house and removing parking spaces, thus this would accentuate the aspiration of taking some, while at the meantime give back to the locals and to support utilizing the parking house and its potential to become more multifunctional.

This resulted in utilizing two modules of 2.5 meters each to create space for the new staircases. In addition to implementing the stairs it was aspired to create different purposes and arrivals for each. This resulted in having one stair with seats to invite people for a break or to use as a meeting point.



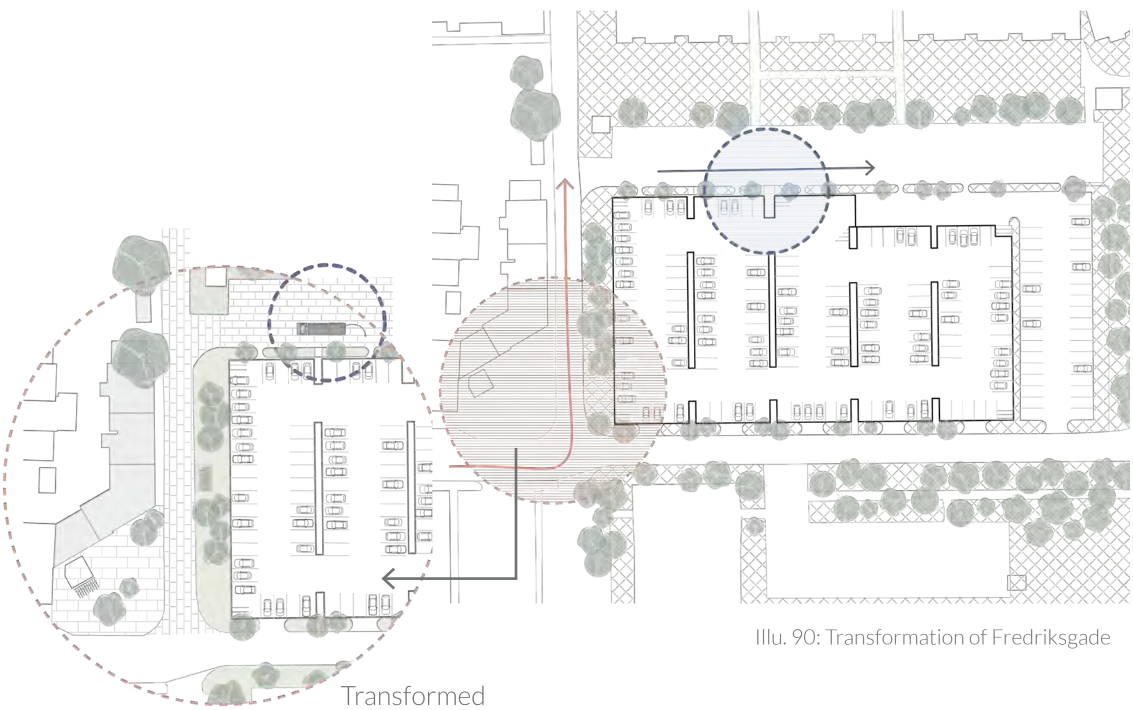
By integrating these different entrances for the uses strengthen the desire of developing an urban catalyst, as the parking house appears more public and inviting. Furthermore, it can offer a safer and including environment up on the added level of the new typology.

Illu. 89: Stair Concept Diagram

Urban programming - Street level

In connection with the arrival points a transformation of Fredriksgade into a throughfare street was constituted into designing a safer and more controlled street environment near the western part of the site. By altering the speed limit of the street created a hierarchy where the pedestrians and cyclists are highest and where the cars can only drive if they have a purpose.

To accentuate the change of speed, new pavements are placed, and more green elements are placed strategically to establish a more open and public space. A further integration of bicycle stands is placed, and a further alteration of the parking houses façade will be explained in a later chapter.



Illu. 90: Transformation of Fredriksgade

Urban programming - Building Level

In connection to programming the outside spaces of the typology, a direct sun hour simulation assisted the placement of zones. The direct sun hour simulation calculates the number of hours direct sun which is received by a defined surface using a set of sun vectors. The results can provide knowledge of where shadow might fall in a defined time of year and day. As the new typology wishes to act as an urban catalyst, different functions and programs need to be integrated to support social activities while at the same time relate to the purpose of the center.

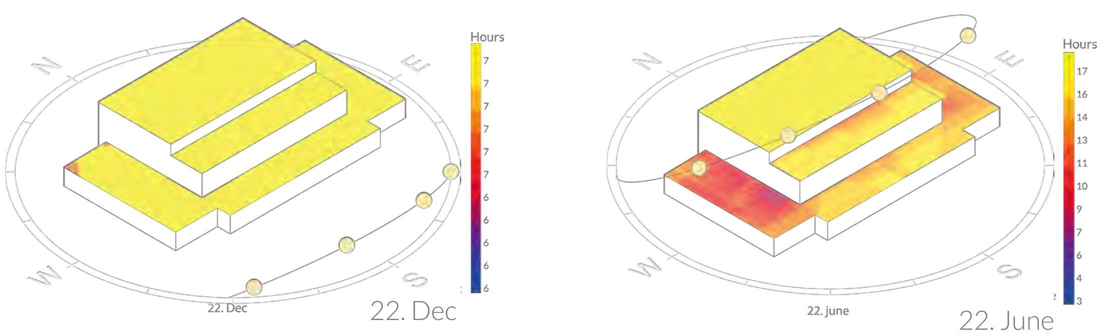
The simulation showed the distribution of direct sunlight in different times of the year where December had the lowest number of hours due to the low altitude of the sun (illu 92). Though this was expected and will not affect the programming, as the outdoor spaces will be used less in the cold months.

The warm months of summer and spring are more interesting for this thesis to examine, as these are the seasons for cultivating the community gardens both in relation to food production and food literacy and sociality.

The results of the simulations showed how the east side would have up to seven hours of direct sunlight (appendix 9), and this became the basis of placing the community garden on that side of the building. In the later hours of the day the local users will likely be home from work, and therefore the community functions were placed towards the west where they can enjoy the different zones, like playgrounds, grill spots, leisure spaces and other elements to providing them with a courtyard atmosphere.

Towards the south and in relation to the entrance of the building a more plaza atmosphere was aspired to, where the spaces inside could expand and melt into the outside. As an example, having outdoor areas in relation to the café.

Following the programming of the spaces around the building, an organization of zones was developed on the roof top garden. With inspiration from Østergro it was desired to design a rooftop garden which could both offer to food productivity but also food related social activities. As an example, having an outdoor kitchen in connection to the cooking class workshop and a terrace together with the greenhouse.



Illu. 91: Direct sunlight hour simulations

Illu. 92: Programming of Exterior Spaces and Rooftop Terrace

Interfering with the Parking Structure

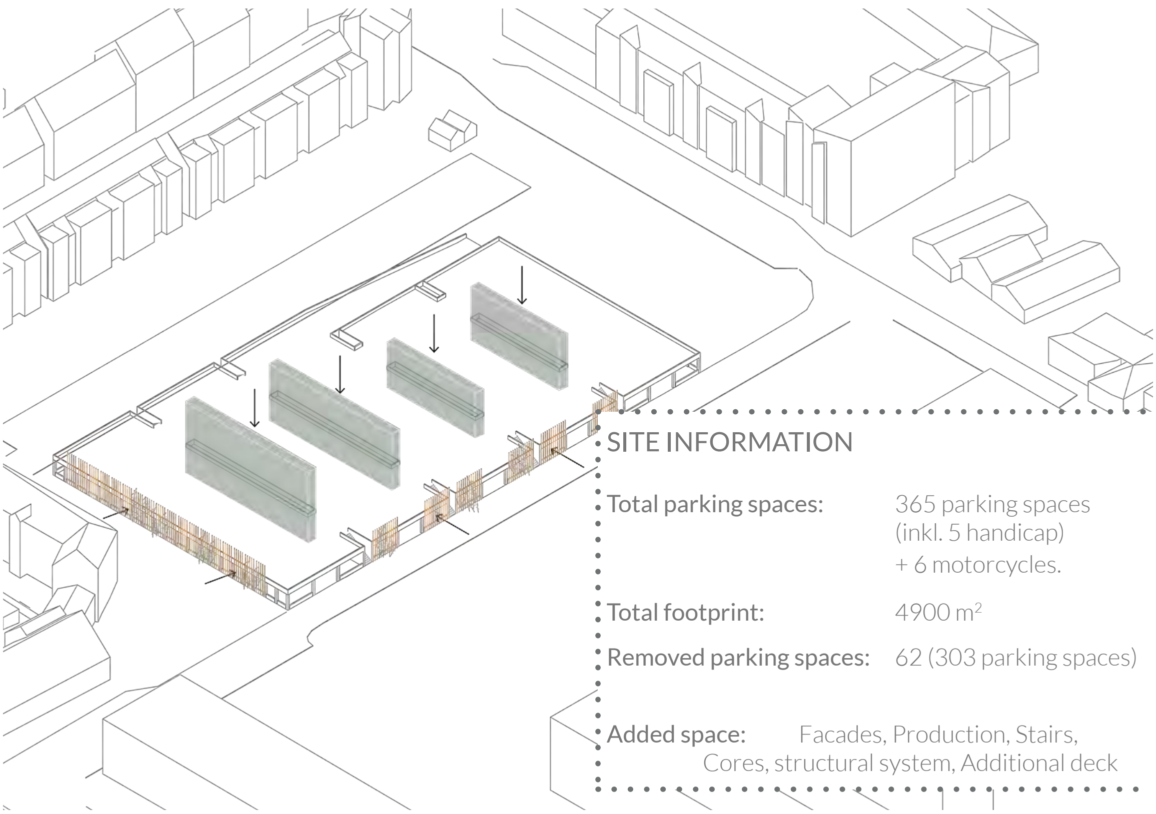
To support the potential of utilizing the parking house and create a multifunctional urban space, the new typology aspires to create a visible transformation and alteration of the parking houses appearance. Which will involve removing parking lots, but in return giving back to the locals by developing a public space.

To accomplish a visible change to the parking structure a transformation of the overall appearance of the façade will be developed. Though the function of car parking will not be hidden but rather become more appealing and enhance to a safer and more open atmosphere on the inside.

This will be done by removing the old lattice which the vegetation climbs and exchanging it with a new transparent cladding like slats to enhance a symmetry with the newly built environment, while adding evergreen plantation like ivy, which gives a green atmosphere year around.

A further change is to integrate some of the production down into the parking space to enhance a visible peek into the cultivation center and to serve the practicality of food production.

The overall transformation of the parking house resulted in removing 63 Parking spaces of the current 365 which was necessary to use the potential parking house for the concept.



SITE INFORMATION

Total parking spaces: 365 parking spaces (inkl. 5 handicap) + 6 motorcycles.

Total footprint: 4900 m^2

Removed parking spaces: 62 (303 parking spaces)

Added space: Facades, Production, Stairs, Cores, structural system, Additional deck

Illu. 93: Parking house production shafts

Façades

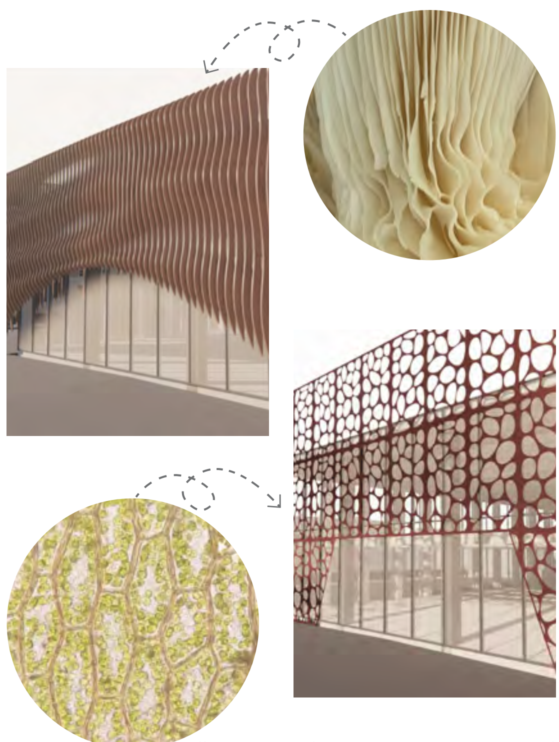
To support the potential of utilizing the parking house and create a multifunctional urban space, the new typology aspires to create a visible transformation and alteration of the parking houses appearance. Which will involve removing parking lots, but in return giving back to the locals by developing a public space.

To accomplish a visible change to the parking structure a transformation of the overall appearance of the façade will be developed. Though the function of car parking will not be hidden but rather become more appealing and enhance to a safer and more open atmosphere on the inside.

Illu. 94: Material Boards

This will be done by removing the old lattice which the vegetation climbs and exchanging it with a new transparent cladding like slats to enhance a symmetry with the newly built environment, while adding evergreen plantation like ivy, which gives a green atmosphere year around.

A further change is to integrate some of the production down into the parking space to enhance a visible peek into the cultivation center and to serve the practicality of food production.



Illu. 95: Visualisations of facade proposal

The overall transformation of the parking house resulted in removing 63 Parking spaces of the current 365 which was necessary to use the potential parking house for the concept.

Fenestration

Subsequently this façade seemed too private and cluttered, which concluded with a new proposal and alteration of the atrium. The new proposal emphasizes a simple appearance in its rhythm and translates the internal floors on the outside horizontally beams. The vertical slats enhance the verticality of the building, while also providing shading from east and west.

The minimal cladding material contributes to the clean façade, where atrium with its open appearance standout and supports the typology as a public and inviting building. Further investigation of the fenestration and the materials was examined parallel to the process of the façade expression.

Illu. 96: Fenestration and facade expression

The fenestration strategy was created by letting the façade dictate the form and size of the windows. The placement of the windows was dictated by the functions within the given space.

Interwoven calculations have been conducted to examine the temperature in both the atrium (see page 100) and the smaller spaces towards the south, as an example the mushroom workshop and the café, to see the possibility of heat gain by the direct sunlight. As part of ensuring a comfortable indoor climate the 24-hour average calculations for the café showed an average temperature in July at 24.9°C and a maximum of 27.6°C (appendix 6).

When using ventilation with a constant temperature 2°C lower than the outdoor 24-hour average temperature, the average temperature could be brought down to 23.4°C. These calculations showed a need for some outdoor shading on the south and east façade of the café. With this shading it was possible to keep the windows from floor to ceiling.

Values used for the Cafe:

Window area: 290 m^2
G-value: 0.3
$F_{(afsk)}$: 0.6 (North) 0.9 (South)
$F_{(skyg)}$: 0.6 (North) 0.9 (South)
$F_{(glas)}$: 0.9

Ventilation
Air change: 2.0h^{-1}
Infiltration: 0.1h^{-1}

Internal Loads
People: 0/479/2000 W (min./aveage/max)
Total: 100/750/2350W (min./aveage/max)

Values used for the Workshop:

Window area: 111 m^2
G-value: 0.3
$F_{(afsk)}$: 0.6 (North) 0.6 (South)
$F_{(skyg)}$: 0.8 (North) 0.9 (South)
$F_{(glas)}$: 0.9

Ventilation
Air change: 2.0h^{-1}
Infiltration: 0.1h^{-1}

Internal Loads
People: 0/422/1200 W (min./aveage/max)
Total: 100/589/1610W (min./aveage/max)

Results :

Temperature / °C	Ventilation air same temperature as the outside air		Ventilation air constant temperature same as outside air temperature		Ventilation air with constant intake temperature two degrees lower than outside air	
	Cafe	Workshop	Cafe	Workshop	Cafe	Workshop
24-hour average	24.9	24.9	24.9	24.8	23.4	23.5
Variation	5.4	4.7	3.0	2.3	3.5	2.3
Max temperature	27.6	27.2	26.4	26.0	24.9	24.7

The other function on the south façade, the mushroom workshop, was similar in result as the café. With less fenestration, but also a smaller footprint, the workshop had an average temperature in July of 24.8°C and a maximum of 27.2°C (see appendix 7). As in the previous, this is with some outdoor shading.

The calculations showed a heat gain which could be managed by the use of shading applications. This could be exterior shading to control the temperatures on the warmest days. On the east and west facades, vertical slats can help lower the direct sunlight and heat gain in the hours where the sun is at its highest. This investigation showed that heigh windows from floor to ceiling are possible if certain shading strategies are incorporated into the project.

Environmental Impact of Exterior Cladding

Parallel with the facade studies, the exterior materials were investigated and evaluated. First, the cladding material is investigated, and secondly the material for the slats is evaluated.

Cladding

For the base of the facades, four materials were tested and compared: fiber cement, thermo wood, aluminum, and gypsum plaster.

The main cladding had to create a simple base for the facade, while bringing texture and color. Despite its low GWP, the thermo wood was not selected because of its visual appearance. Aluminum has the highest GWP, while not having the appearance wanted for the facade. Therefore, the choice was between fiber cement and stucco. The stucco was chosen because of advantages on more aspects compared to the fiber cement. The stucco has the lowest GWP, smallest thickness, and brings texture and simplicity to the facade.

Therefore, the final choice was stucco for the base layer for cladding.

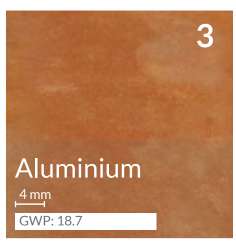
Illu. 97: GWP for exterior cladding materials

Fibre Cement Boards

The boards are an autoclaved calcium silicate eternit fibre cement sheet. It is mainly made of sand, cement, cellulose, wallastonite, clay, and lime.

Thermo Wood

The thermo wood is the thickest of the four materials and brings a different surface to the facade. The facade needs a further treatment to get the wanted red colour.



Aluminium Composite

Aluminium is the thinnest of the four materials, but brings some challenges. The material might bring a challenge on the south facade when the sun heats it up.

Stucco

The finish provides a smooth, flat, high quality surface. It requires a thin layer on top of facade plates.

** GWP: CO_2-eq./m^2/year*

Slats

The slats for the façades are of two types, depending on the material. When using wood, the slats are solid elements, while they are hollow, using metals. Therefore, the GWP is calculated both per cubic meter and for one slat element measuring 1000x200x60 mm.

The graphs show a difference when taking into account the profile of the elements. Because of the smaller material use the two metals drops below the wood on GWP. Now, the materials are more comparable.

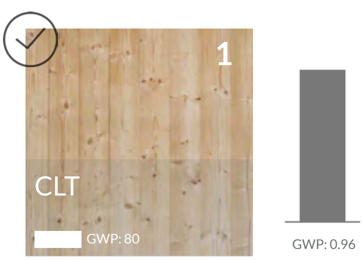
In addition to each material's GWP, the aesthetic and texture of the material is important for the choice. In order to bring more patina and texture to the façades, wood is the better choice of the four. It brings the desired warmth, patina, and texture to the facade.

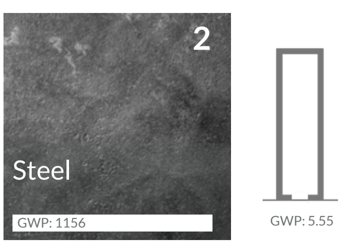
Therefore, the choice was between CLT and plywood, with CLT having the lowest GWP. With the influence of appearance and the GWP, CLT was chosen as the material for the slats.

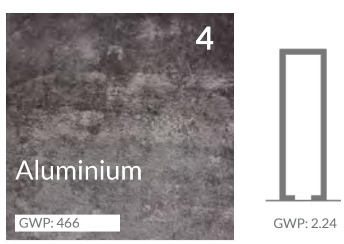
The two materials chosen for the exterior cladding had an influence on the overall GWP for the building. The influence is shown below.

Illu. 98: GWP for exterior slats materials per cubic meter

Illu. 99: GWP for exterior slats element 1000x200x60 mm







GWP Change
Exterior walls

Before:
9.12e-01 CO_2-eq./m^2/year
(-5.91e-01) CO_2-eq./m^2/year

After:
3.21e-01 CO_2-eq./m^2/year

* GWP: CO_2-eq./m^3/year

GWP Change
Overall Building
Before:
8.34e+00 CO_2-eq./m²/year
(-1.85e+00) CO_2-eq./m²/year
After:
6.49e+00 CO_2-eq./m²/year

Overall Environmental Impact of the Building

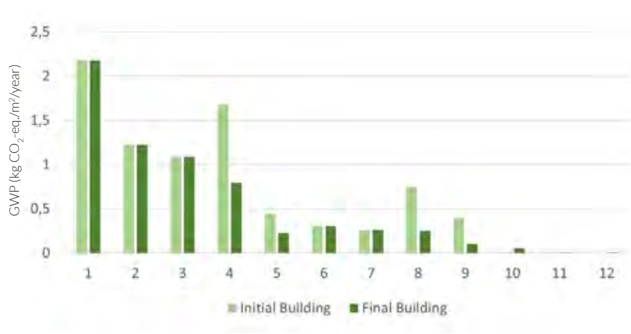
Before finding the overall environmental impact of the building, changes to the roofs are made. Two types of roofs were developed, one normal roof and one for the roof gardens. The normal roof is insulated over the beams, while the roof garden roofs are insulated both over and in between the beams. The insulation chosen for the roof construction is the same as for the exterior walls. With the changes to the roof construction, the GWP was brought down from 1.69 e-00 CO_2-eq./m^2/year to 7.95e-01 CO_2-eq./m^2/year.

The roof construction has to meet the requirements for the Danish Building Regulations of 0.20 W/(m^2K) (BR18, 2021). With calculations and simulations using Ubakus, the roof construction has a thermal conductivity of 0.13 W/(m^2K) (Plag, 2022), meeting the requirements (appendix 14-15).

As the previous process sections have shown, the choices for construction and materials were influenced by the environmental impact based on life cycle assessment. Various studies of different materials were done to establish their properties and potential in terms of their climatic impact and their appearance. Through individual testing and comparisons, the materials were then combined to a final construction. With the changes to the building materials, the building GWP decreased from 8.45 e+00 CO_2-eq./m^2/year to 6.49 e+00 CO_2-eq./m^2/year. An improvement of 1.85 e+00 CO_2-eq./m^2/year. Some of the building components did not bring improvement to the overall GWP. One was the structural system, which was evaluated and improved earlier in the process in separate calculations. Because of the need for a larger structural span and therefore concrete as the main structural material, the largest building component for the building is concrete. Others, such as the heating, ventilation and cooling were calculated as a standard value per m^2. The calculations showed which components took up the largest percentage of the overall GWP. Here, the structural system, floor slabs and heating, ventilation and cooling were the biggest. The improvement on the roof construction brought down the percentage influence on the overall GWP.

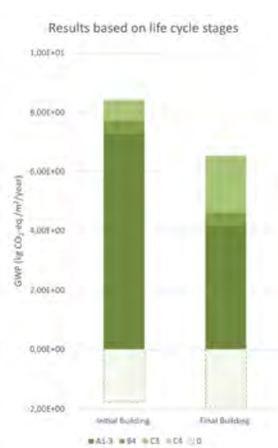
Conclusively, the LCA process had an influence on the overall choices of materials and construction.

Comparison of building components, CO_2-eq./m^2/year (GWP)



Illu. 100: GWP comparison of building components

GWP results based on phases



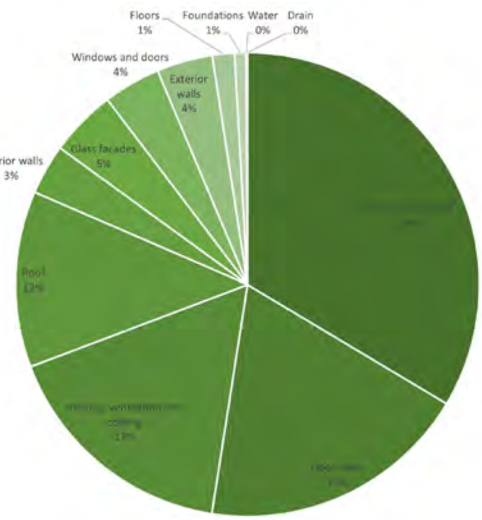
Illu. 101: GWP graph for final and initial building

Final Building Components

	Building component	Total w/o D
1	Structural system	2.180e+00
2	Floor slabs	1.226e+00
3	Heating, ventilation, and cooling	1.090e+00
4	Roof	7.954e-01
5	Interior walls	2.2283e-01
6	Glass facades	3.023e-01
7	Windows and doors	2.558e-01
8	Exterior walls	2,530e-01
9	Floors	1.003e-01
10	Foundations	5.216e-02
11	Water	3.050e-02
12	Drain	3.000e-02
	Total	6.492e+00

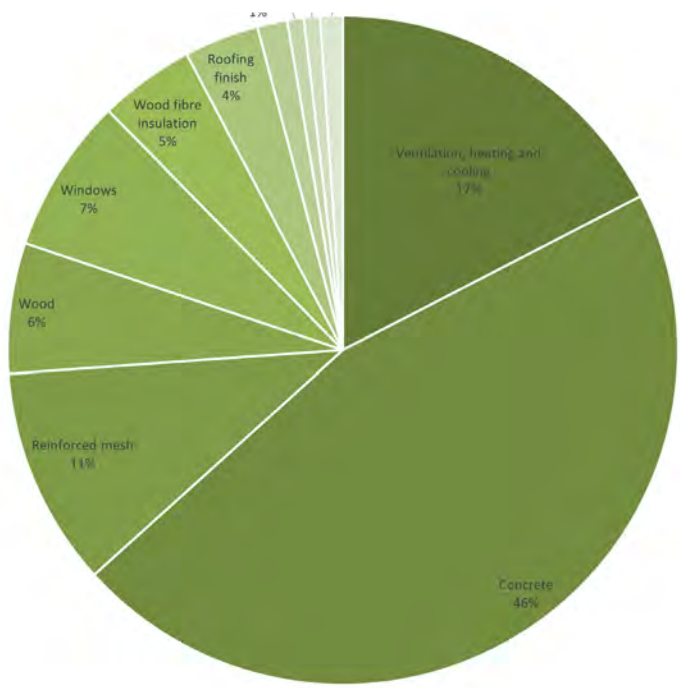
Unit: CO_2-eq./m²/year

Distribution of building components' GWP for the final building



Illu. 102: Percentage building components, final building, GWP

GWP results based on Material Components



Conclusion

The design proposal for the new urban cultivation center Grobunden, addresses many of modern times issues of urbanization and food security. The typology becomes a landmark by providing fresh greens in the center of the city, and therefore reduces the need of utilizing nature for agricultural land.

Through a sustainable approach the proposal presents the opportunity of transforming existing urban developments to create multifunctional spaces that can promote food and enhance lively activity. The typology embraces the surroundings through its form and scale and provides new relevance to the otherwise monofunctional space.

By using innovative sustainable farming methods, such as hydroponic systems, mushroom farms and microgreens, the building contributes to sustainable and efficient food production and ensures fresh year-round yield crops.

Summarizing knowledge of theory and analysis, the new typology is a beacon to the city of Aalborg as a multifunctional space which embraces its surroundings. Through its food-related programs, it promotes knowledge and strengthens social bonds, resulting in an environmentally and socially sustainable architectural design proposal which accommodates the stated problem of acting as a new catalyst.

The incorporated food production, food related workshops and exhibitions encourage to rediscover the infrastructure of our food systems. And therefore, changing the tendency from buying and consuming to instead take part in dynamics of planting, growing, preparing and eating.

Synthesizing the proposed aspiration of creating a carbon reduced building, through calculations and defined considerations of material, function and form the building meets the new building requirements for GWP of 12 kg CO_2-eq./m^2/year with a total of 6.5 CO_2-eq./m^2/year. Furthermore, the use of passive and active means together with its program the building acts as its own artificial ecosystem.

Conclusively the proposal Grobunden is a solution to the future development of a hybridization of modern agriculture and urban cityscapes.

Reflection

Accumulated, the presented thesis and the complexity of developing a new typology using an existing site, depended on multiple theories and analysis to assist defining the project scope and solving the problematics.

Transforming the parking structure and reusing the existing structural system as a base for the new development was especially a challenge due to its function of parking together with the discussion of what to preserve and what to disregard. From the beginning of the process, it was a premise to preserve as many parking spaces as possible, due to the short life span of the parking house and the local demand for parking. Therefore, interfering too much with the existing structure would go against this premise of building something that lasts for decades.

This leads to the question of whether the project would have been better off at another location, due to the fact of the many decisions which have been on behalf of the parking structure or if the cultivation center really reached the unresolved potentials on the site, and for itself, by being a multifunctional typology.

Through the aspiration of creating catalyst architecture, the physical alteration of a place together with its placement and program have a positive ability to change the dynamics of social activities and city life. Therefore, the programming of the building was a main aspect of the process to ensure the building could become a new beacon to the city.

When programming a multifunctional building, the building has to consider its various functions' needs and how a combination and organization of these can be combined to a complete typology. When considering these combinations and relations, the question of whether the functions would have been more efficient in separate locations rather than in one collective facility is raised. It is possible to argue that functions such as production and parking would have been more efficient separately from the other functions. On the other hand, collecting all these functions into a single typology brings other benefits regarding food literacy, bringing life to a before monofunctional structure, creating an urban catalyst etc. It might be discussed whether the benefits from social and educational achievements exceed the productivity of separating functions like production.

The challenge of creating a balance between food literacy and food production contributed to many alterations of the form, organization and overall appearance of the process. The final distribution was first found in the late phases, by creating clear delimitations and hierarchy in the distribution of square meters in the floorplans.

The hybridization of designing a cultivation center on top of an existing parking house puts the final proposal into retrospect concerning if the function of a cultivation center is valid enough to last. In regard to its use, other examples such as House of Grain or other food related typologies have a tendency to be a onetime experience rather than being part of daily life. By adding professional food production into the building, this keeps the concept renewable.

But as technologies evolve, the future for urban cultivation is uncertain. Meaning the building allows for serving other purposes if necessary.

Furthermore, integrating food production within the cityscapes takes up space which could have been utilized for residential housing and then considering other forward problematics of urbanization. But by integrating other functions such as food literacy programs the proposal considers life in the city and therefore avoids becoming yet another monofunctional space.

The cultivation center provides a glimpse into a future resilient smart solution of food security- and literacy, but the question of placement onto the existing parking space contradicts the current reliant of private vehicles. The continued life experienced in the cities today makes it unavoidable to consider some of these requirements rather than contradicting them. Though in a more utopian mind set a space like City Syd could be interpreted as the vehicles answer to a shopping mall, on contrary in the dense city center vehicles are stacked in parking houses.

The aspiration of reaching the new building regulations concerning reducing the carbon emission in the building sector, the calculation program LCAbyg have been utilized throughout the process to check the building overall global warming potential. Though it is important to state that even though the building meets the requirement of 12.0 kg CO_2-eq./m^2/year, there are certain factors which have been discarded due to the complexity of the calculation, some of these contribute to outdoor areas, screws and basic standards of water, heat have been included in the final result.

Illu. 103: Microgreens - pea sprouts fully grown

Bibliography

Aalborg Kommune (2016) 1.1.D12 Nordlige del af Håndværkerkvarteret, http://www.aalborg-kommuneplan.dk/.

Aalborg Kommune (2019) 'Budolfi Plads'. Aalborg . Available at: https://www.aalborg.dk/om-kommunen/byplanlaegning/byudvikling/budolfi-plads (Accessed: 20 February 2023).

Aalborg Kommune (2022) 'Befolknings- og Boligforhold ', Aalborg i Tal [Preprint]. Aalborg.

Aalborg Kommune, T.F. (2004) Lokalplan 10-070, Boliger og erhverv mellem Jyllandsgade og Toldstrupsgade. Aalborg.

Bellotti, B. (2010) 'Food Literacy: Reconnecting the City with the Country', Agricultural Science , 22(3), pp. 29–34.

van den Berg, J. and Konings, B. (2019) 'Material Atlas / the Growing Pavilion'. Available at: www.companynewheroes.com (Accessed: 8 February 2023).

den Digitale Byport: Danmarks Købstræder (2012) 'Aalborg', Danmarkshistorien [Preprint]. Aarhus: Aarhus Universitet.

Doron, G. (2005) 'Urban agriculture: Small, medium, large', Architectural Design, 75(3). Available at: https://doi.org/10.1002/ad.76.

Van Gerrewey, T., Boon, N. and Geelen, D. (2022) 'Vertical farming: The only way is up?', Agronomy. Available at: https://doi.org/10.3390/agronomy12010002.

https://carloratti.com/project/fico-area-del-futuro/ (2017) Hortus at FICO Eataly World , Ratti, Carlo.

Kalantari, F. et al. (2018) 'Opportunities and challenges in sustainability of vertical farming: A review', Journal of Landscape Ecology(Czech Republic), 11(1). Available at: https://doi.org/10.1515/jlecol-2017-0016.

Kiib, H. and Marling, G. (2015) Catalyst Architecture. Aalborg: Aalborg Univerity Press.

Knudstrup, M.-A. (2004) 'Integrated Design Proces in Problem-Based Learning ', The Aalborg PBL Model: Progress, Diversity and Challenges . Aalborg : Aalborg Universitetsforlag , pp. 221–234.

Lim, C.J. and Liu, E. (2019a) Smartcities, Resilient Landscapes and Eco-Warriors, Smartcities, Resilient Landscapes and Eco-Warriors. Available at: https://doi.org/10.4324/9781351110037.

Lim, C.J. and Liu, E. (2019b) Smartcities, Resilient Landscapes and Eco-Warriors, Smartcities, Resilient Landscapes and Eco-Warriors. Available at: https://doi.org/10.4324/9781351110037.

Nielsen. H, M. et al. (2019) Anbefalinger til regeringen fra Klimapartnerskabet for bygge-og anlaegssektoren. København. Available at: https://kefm.dk/klima-og-vejr/regeringens-klimapartnerskaber-og-groent-erhvervsforum (Accessed: 16 February 2023).

Nordahl, D. (2014) 'Food Literacy', in Public Produce: Cultivating Our Parks, Plazas, and Streets for Healthier Cities . 2nd edn. Island Press, pp. 145–169.

Nordic Harvest A/S (2023) Nordic Harvest .

Østergro (2022) Østergro, https://www.oestergro.dk/om-stergro . Available at: https://www.oestergro.dk/ (Accessed: 14 February 2023).

Plag, F. (2022) Ubakus.de, Ubakus.

Ramsted, R. (2020) House of Grain / Reiulf Ramstad Arkitekter, https://www.archdaily.com/.

Ritchie, H. (2018) How Urban is the World? - Our World in Data, Our World in Data.

Ritchie, H. and Roser, M. (2019) Land Use - Our World in Data, Our world in data.

Ritchie, H. and Roser, M. (2022) Environmental Impacts of Food Production - Our World in Data, Our World in Data.

Ritchie, H., Spooner, F. and Roser, M. (2022) Biodiveristy - Our World in Data, Our World in Data.

Rockwool (2023) Den Frivillige Bygningsklasse 2020 (lavenergiklasse).

Roser, M., Ritchie, H. and Ortiz-Ospina, E. (2020) World Population Growth- Our World in Data, Population Reference Bureau.

Siim Karro and Killu Leet (2022) Mycelium Materials: The Future of Growing our Homes, https://www.archdaily.com/985570/mycelium-materials-the-future-of-growing-our-homes.

Steel, C. (2015) 'Hungry City: How Food Shapes Our Lives', Future of Food: Journal on Food, Agriculture and Society.

Stren, R. and Polése, M. (2000) 'The Social Sustainability of Cities: Diversity and the Management of Change', University of Toronto Press, pp. 23–57.

Termansen, L. (2012) 'Parkering i to plan', https://nordjyske.dk/, 6 January.

The British Design Counsil (2005) A Study of the Design Process . London.

Trafik-, B.B. (2021) 'Danish Building Regulation ', in Bygningsrelement 2018. 3rd edn. Molio. Available at: https://bygningsreglementet.dk/Tekniske-bestemmelser/11/Krav/257#3e7c9938-9116-46a9-b468-2a571006ca9b (Accessed: 9 May 2023).

UNFCCC (2020) What is the Paris Agreement? | UNFCCC, United Nations Climate Change. Available at: https://unfccc.int/process-and-meetings/the-paris-agreement/what-is-the-paris-agreement.

Videnscenter for bygningers klimapåvirkninger (2022) LCA ifølge klimakravene - Introduktion til LCA i henhold til klimakravene i bygningsreglementet. Available at: https://byggeriogklima.dk/viden/ (Accessed: 16 February 2023).

Videnscenter for bygningers klimapåvirkninger (2023) 'Klimakrav/ Kort om kravene', https://byggeriogklima.dk [Preprint]. Videnscenter om Bygningers Klimapåvirkninger .

WCED (2018) 'Report of the World Commission on Environment and Development: Our Common Future: Report of the World Commission on Environment and Development', World Commission on Environment and Development, pp. 1–300. Available at: http://www.un-documents.net/our-common-future.pdf%5Cninternal-pdf://547/our-common-future.html.

EPD References List

EPD Danmark (2021a) 'EPD_MD-20007-EN_Træ_CLT'. epddanmark.

EPD Danmark (2021b) 'EPD_MD-20008-EN_Træ_Plywood'. epddanmark.

EPD Danmark (2022a) 'EPD_MD-19009-EN_Junckers Industrier A/S'. epddanmark.

EPD Danmark (2022b) 'EPD_MD-21091-EN_Knauf A/S_Gypsum Plasterboard'. epddanmark.

EPD Danmark (2022c) 'EPD_MD-22066-DA_A/S Ikast Betonvarefabrik'. epddanmark.

EPD Danmark (2023) 'EPD_MD-23014-EN_Frøslev'. epddanmark.

EPD Internation AB (2019) 'EPD_S-P-00506_British Gypsum_Gypsum board'. EPD International AB.

EPD International (2022) 'EPD_S-P-06174_ISOMAT_Flowcret '. EPD International .

EPD International AB (2020) 'EPD_S-P-01848_Kanuf_Rock Wool Insualtion '. EPD International AB.

EPD International AB (2021a) 'EPD_S-P-00584_Saint-Gobain Construction '. EPD International AB.

EPD International AB (2021b) 'EPD_S-P-04587_Knauf AS_Mineral Wool'. EPD International AB.

EPD International AB (2022) 'EPD_S-P-01850_Norbod_OSB Board'. EPD International AB.

The Norwegian EPD Foundation (2020) 'EPD_NERP-2287-1041-NO_Hunton_Wood Fibre Insulation'. epd-norge.

The Norwegian EPD Foundation (2022) 'EPD_NERP-3293-1904-EN_RaniMoBar'. epd-norge .

The Norwegian EPD foundation (2022) 'EPD_NERP-4037-3072-EN_Hunton'. The Norwegian EPD foundation .

The Norwegian EPD Foundation (2023) 'EPD_NERP-3381-2002_Rockwool '. The Norwegian EPD Foundation .

UL Environment (2018) 'EPD_12CA64879.101.1_Forbo Flooring B.V'. UL Environment .

Bau EPD GmbH (2014) 'EPD_ISOCELL-2014-1-GaBi_Cellulose'. Bau EPD GmbH.

Illustration List

Illu. 1 – own illustration

Illu. 2 – 3 Own photo

Illu. 4 – own illustration

Illu. 5 - Own photo

Illu. 6 – 7 own diagrams with CC pictures

Illu 8-11 own illustration

Illu. 12 own diagrams with CC pictures

Photo used:

(https://www.google.com/search?q=demolishing&tbm=isch&tbs=il:cl&hl=da&sa=X&ved=0CAAQ1vwEahcKEwjYyvDBv5n9AhUAAAAAHQAAAAAQAw&biw=941&bih=902#imgrc=RZ2f-W0M7FNaOM)16.2.2023

(https://www.patternpictures.com/wp-content/uploads/Pile-of-Bricks-patternpictures-5305.jpg) 16.2.2023

(https://www.google.com/search?q=forrest&tbm=isch&hl=da&tbs=il:cl&sa=X&ved=0CAAQ1vwEahcKEwiYoq-Dh5z9AhUAAAAAHQAAAAAQAw&biw=1903&bih=929#imgrc=eLLxStKJTxkVaM)

Illu. 13 own diagrams with CC pictures

Lca diagram

https://upload.wikimedia.org/wikipedia/commons/4/43/2021-05-21-Construction-work-Benrodestrasse-foto3.jpg

https://www.google.com/search?q=skov&tbm=isch&hl=da&tbs=il:cl&sa=X&ved=0CAAQ1vwEahcKEwioi7qhpbP9AhUAAAAAHQAAAAAQAw&biw=1903&bih=872#imgrc=__fJI94Wbs2HuM

https://www.google.com/search?q=building%20maintenance&tbm=isch&hl=da&tbs=il:cl&sa=X&ved=0CAAQ1vwEahcKEwiI8-fNtrP9AhUAAAAAHQAAAAAQCA&biw=1903&bih=872#imgrc=AWu0BBK4l5gxTM

https://www.google.com/search?q=ressourcer%C3%A6kkerne&tbm=isch&tbs=il:cl&hl=da&sa=X&ved=0CAAQ1vwEahcKEwig2PS03rP9AhUAAAAAHQAAAAAQAw&biw=1903&bih=872#imgrc=PKuLQwH8SdP-xM

https://www.google.com/search?q=affaldsforbr%C3%A6nding&tbm=isch&hl=da&tbs&sa=X&ved=0CAEQpwVqFwoTCMjK6M3os_0CFQAAAAAdAAAAABAD&biw=1903&bih=855#imgrc=ZotL3CJAIGcucM

Illu.. 14- 17

Illu. 18 own photos

Illu. 19 – 20

Aalborg historie

Billede B13932 og B52758 fra Arkiv.dk (Tilladelse godkendt af Aalborg Stadsarkiv)

Kirkegaard, J. A. (1953) Børn leger på Sauers Plads (Trækbanen), B13932. Available at: https://www.aalborgstadsarkiv.dk/AalborgStadsarkiv.asp?Link=851-01B13932 (Accessed 21 March 2023).

Arial Picture of Aalborg 1960-1965 (n.d.), Luftfoto over Aalborg. I midten Th. Sauers Plads (Trækbanen), B52758. Available at: https://www.aalborgstadsarkiv.dk/AalborgStadsarkiv.asp?Link=851-01B52758 (Accessed 21 March 2023)

Illu. 21-28 own illustrations

Illu. 29 own photos

Illu. 30-46 own illustrations

Illu. 47-52 own photos

Illu. 53-55 own illustrations

Illu. 56 own photo

Illu. 57- 79 own illusrations

Illu. 80 own photos

Illu. 81-94 own illustrations

Illu. 95 own photo

Illu 96 own illustrations and CC used photo:

ttps://www.google.com/search?q=bladceller&tbm=isch&tbs=il:cl&hl=da&sa=X&ved=0CAAQ1vwEahcKEwjwluDUiov_AhUAAAAAHQAAAAAQAw&biw=1903&bih=929#imgrc=nf72Uf3uvBsrWM

Illu. 97-103

Illu. 104 own photo

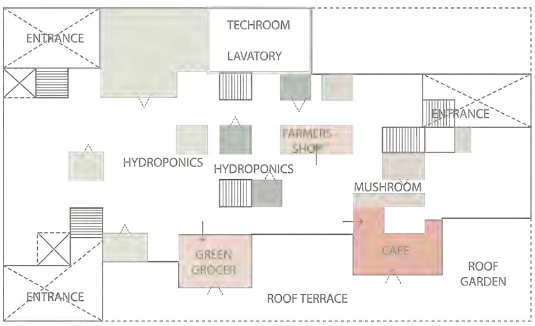
Appendix

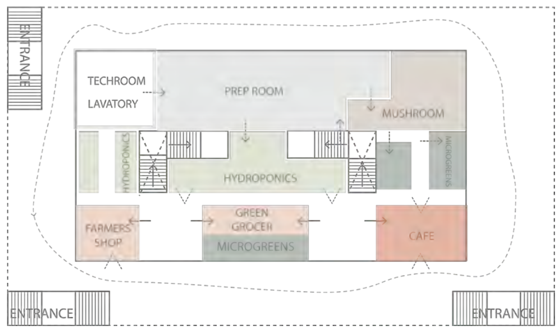
Appendix 1
Organization of Functions

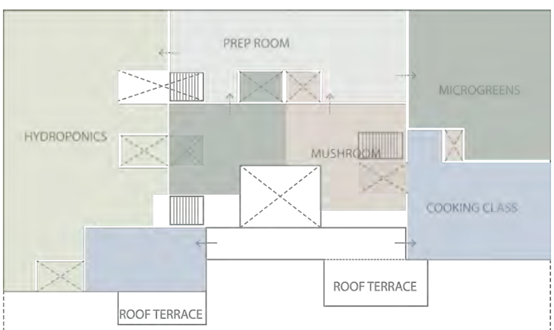
These plans constitute to the full organization of the different plan layouts of the plaza, compact and central concept,

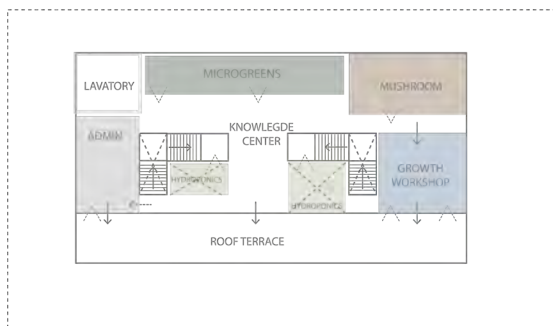
The Plaza plan organization

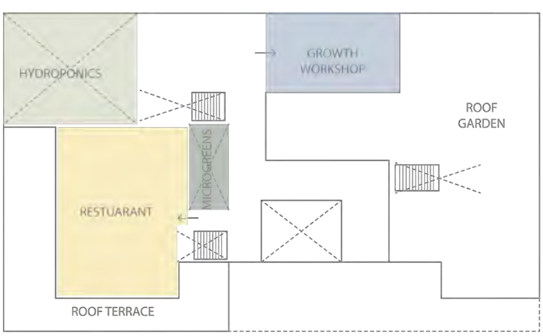
The Central plan organization

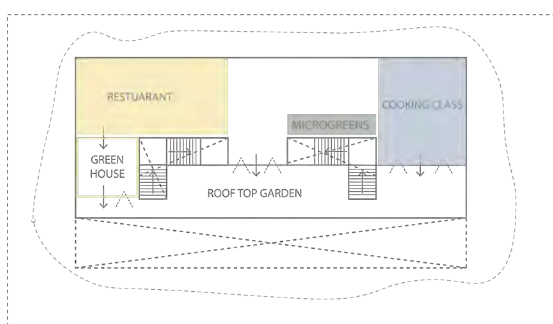




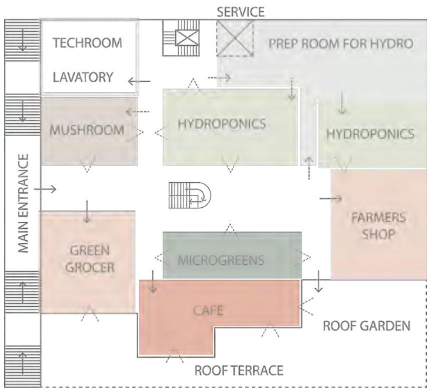


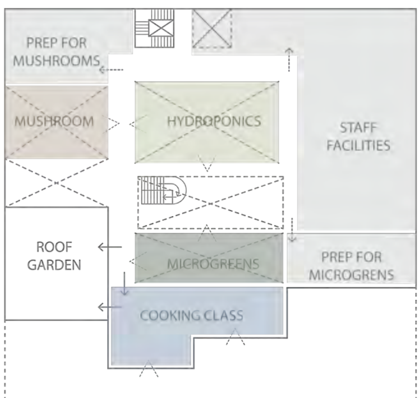


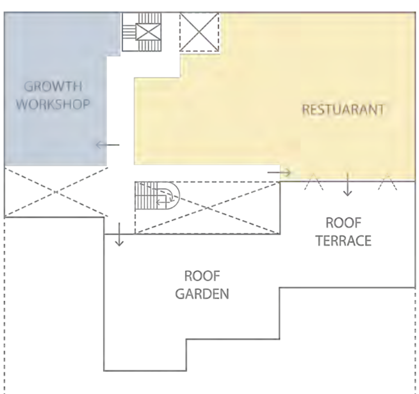




The Compact plan organization







Appendix 2
24-hour average Temperature Estimate: Atrium minimal Fenestration

Beregning af døgnmiddeltemperatur
med danske vejrdata

AALBORG UNIVERSITET
ARCHITECTURAL ENGINEERING

Projekt:
Grobunden - Atrium

Rumopbygning

Hvis der ikke vises kommentarer aktiveres disse under "Vis"

Konstruktioner mod det fri

Nr	Flade	A m^2	U W/m^2K	Bu W/K	
1	Sydvæg	161,00	0,11	17,71	
2	Nordvæg	85,50	0,11	9,41	
3	Tag	685,80	0,13	89,15	
4	Gulv	690,00	0,13	89,70	
5				0,00	
	Sum	1622,30		205,97	= Bukon

Vinduer mod det fri

Nr	Flade	Antal stk	A m^2	U W/m^2K	Bu W/K	Orient grader	Hældning 90/45/0	g-værdi [-]	f(beta) [-]	f(afsk) [-]	f(skyg) [-]	f(glas) [-]	Fsol [-]
1	Syd, vinduer	1	55,00	0,90	49,50	180	90	0,48	0,90	0,40	0,70	0,90	0,11
2	Tagvinduer, tagterrasse	1	4,20	0,90	3,78	180	0	0,48	0,90	1,00	0,80	0,90	0,31
3	Tagvinduer, taget	1	60,00	0,90	54,00	180	0	0,48	0,90	1,00	0,80	0,90	0,31
4	Nord, vinduer	1	58,50	0,90	52,65	0	90	0,48	0,90	0,90	0,90	0,90	0,31
5					0,00								0,00
	Sum	4	177,70		159,93	= Buvin							
	Samlet specifikt varmetab mod det fri Bt				**365,90**	**= Bt = Bukon+Buvin**							

Konstruktioner mod gulv samt omgivende rum

Nr	Flade	A m^2	U W/m^2K	Br W/K	tr °C	Br*tr W	
1	Sidevægge	700,00	0,30	210,00	24,00	5040,00	
2				0,00	24,00	0,00	
3				0,00		0,00	
4				0,00		0,00	
5				0,00		0,00	
	Sum	700		210,00		**5040,00**	**=Σ Br*tr**
	Samlet specifikt varmetab mod omgivende rum Br			**210,00**	**= Br**		

Jordtemperatur for område valgt i "BELA
7,6 °C

Ventilation

	Type	Luftskifte h^{-1}	Rum volum m^3	Luftstrøm m^3/s	Densitet kg/m^3	Varmekap. J/kgK	BL W/K	
1	Ventilation	1,30	6300,00	2,275	1,2	1006	2746,38	
2	Infiltration	0,10	6300,00	0,175	1,2	1006	211,26	
	Sum	1,4		2,450			2957,64	
	Samlet specifikt varmetab ved ventilation BL						**2957,64**	**= BL**

Kontrol
Samlet luftstrøm
liter pr. m^2 gulvareal
3,6

Varmeakkumulering

	Vælg varmeakkumulering	Akk.evne W/K pr m^2	Gulvareal m^2	Ba W/K	
1	Middel let	8	690,00	5520,00	
	Samlet specifik varmeakkumulering Ba			**5520,00**	**= Ba**

Beskrivelse af valgt rumopbygning
Rum med indvendige vægge af letbeton og kun uvæsentlige tunge konstruktionsdele

BELASTNINGER
Gå til ark BELAST

Beregning af belastninger

Projekt:
Grobunden - Atrium
Interne belastninger

Time	Personbelast W	Belysning W	Andet W	Sum W
1	0	0	100	100
2	0	0	100	100
3	0	0	100	100
4	0	0	100	100
5	0	0	100	100
6	0	0	100	100
7	0	1000	100	1100
8	1000	500	100	1600
9	1000	500	100	1600
10	1300	100	100	1500
11	1300	100	100	1500
12	1500	250	100	1850
13	2000	250	100	2350
14	3000	250	100	3350
15	4500	250	100	4850
16	4500	1000	100	5600
17	4500	2000	100	6600
18	4000	2500	100	6600
19	3500	2500	100	6100
20	2000	2500	100	4600
21	1500	2500	100	4100
22	1000	2500	100	3600
23	0	0	100	100
24	0	0	100	100
Sum	36600	18700	2400	57700
Middelværdi	1525	779	100	2404 =Φi
Max. timeværdi	4500	2500	100	6600 =Φimax
Min. timeværdi	0	0	100	100 =Φimin

Pr. m^2 gulvareal	Personbelast W/m^2	Belysning W/m^2	Andet W/m^2	Sum W/m^2
Middelværdi	2,21	1,13	0,14	3,48
Max. timeværdi	6,52	3,62	0,14	9,57
Min. timeværdi	0,00	0,00	0,14	0,14

Beregninger
Gå til ark RESULT

Eksterne belastninger

Vælg område
København

Vælg måned
Juli

Udetemperatur: døgnm	21	°C	= tu
variation	12	°C	= Δtu

Solindfald vinduer	Areal m^3	Orientering grader	Hældning grader	Fsol [-]	Φs W	Φsmax W
1	55,00	180	90	0,11	1184	3988
2	4,20	180	0	0,31	436	1167
3	60,00	180	0	0,31	6225	16666
4	58,50	0	90	0,31	1871	4680
5	0,00	0	0	0,00	0	0
Samlet solindfald i rum					9716	26499

Hjælp til interne belastninger

Personvarme:	Aktivitet met	Total W/person	Fri varme W/person	Antal pers	Fri i alt W
	1,6	158	96	50	4794

Belysning: almen	Niveau lux	Glødelys W/m^2 g.a.	Lysstof W/m^2 g.a.	Lavenergi W/m^2 g.a.	Vælg effekt W/m^2 g.a.	Belysning i alt W
	100	26	8	4	4	2760

Særbelysning
Kontorudstyr

Resultater

Projekt:
Grobunden - Atrium

For valgt måned:	Juli	tu =	21 °C

Hvis ventilationsluften har samme temperatur som udeluften

Døgnmiddeltemperatur	ti =	24,6	°C
Temperaturvariation	Δti =	6,6	°C
Maksimaltemperatur	timax =	27,9	°C

$$t_i = \frac{B_t t_u + \sum B_r t_r + B_L t_L + \mathbf{\Phi_i} + \mathbf{\Phi_s}}{B_t + \sum B_r + B_L}$$

$$\Delta t_i = t_{imax} - t_{imin} = \frac{\Delta\Phi_K}{B_t + \sum \mathbf{B_r} + B_L + B_{akk}}$$

$$\mathbf{\Delta\Phi_k = \Delta\Phi_{k1} + \Delta\Phi_{k2}}$$

$$\mathbf{\Delta\Phi_{k1} = \frac{2}{3}[(\Phi_i + \Phi_s)_{max} - \Phi_{i,min}]}$$

$$\mathbf{\Delta\Phi_{k2} = \Delta t_u (B_{u,vin} + B_L)}$$

Supplerende beregninger

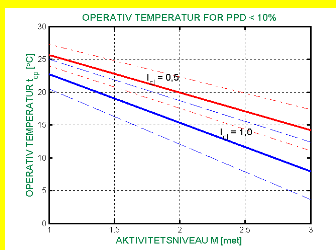
Hvis ventilationsluften har konstant temperatur lig udeluftens døgnmiddeltemperatur

Døgnmiddeltemperatur	ti =	24,6	°C
Temperaturvariation	Δti =	2,9	°C
Maksimaltemperatur	timax =	26,1	°C

Beregning hvor ventilationsluften har konstant indblæsningstemperatur der er Δt = 2 °C lavere end udeluftens døgnmiddeltemperatur

Hvis ventilationsluften har konstant temperatur på 19 °C

Døgnmiddeltemperatur	ti =	22,9	°C
Temperaturvariation	Δti =	2,9	°C
Maksimaltemperatur	timax =	24,4	°C



Figuren er optegnet på grundlag af regression på tabelværdier i anneks E i DS/ISO 7730.

Appendix 3
24-hour Average Temperature Estimate: Atrium Open facade

Beregning af døgnmiddeltemperatur
med danske vejrdata

AALBORG UNIVERSITET
ARCHITECTURAL ENGINEERING

Projekt:
Grobunden - Atrium

Rumopbygning

Hvis der ikke vises kommentarer aktiveres disse under "Vis"

Konstruktioner mod det fri

Nr	Flade	A m^2	U W/m^2K	Bu W/K	
1	Sydvæg	124,00	0,11	13,64	
2	Nordvæg	52,00	0,11	5,72	
3	Tag	690,00	0,13	89,70	
4	Gulv	690,00	0,13	89,70	
5				0,00	
	Sum	1556,00		198,76	= Bukon

Vinduer mod det fri

Nr	Flade	Antal stk	A m^2	U W/m^2K	Bu W/K	Orient grader	Hældning 90/45/0	g-værdi [-]	f(beta) [-]	f(afsk) [-]	f(skyg) [-]	f(glas) [-]	Fsol [-]
1	Syd, vinduer	1	110,00	0,90	99,00	180	90	0,48	0,90	0,40	0,70	0,90	0,11
2	Tagvinduer, tagterrasse	1	0,00	0,90	0,00	180	0	0,48	0,90	1,00	0,80	0,90	0,31
3	Tagvinduer, taget	1	60,00	0,90	54,00	180	0	0,48	0,90	1,00	0,80	0,90	0,31
4	Nord, vinduer	1	110,00	0,90	99,00	0	90	0,48	0,90	0,90	0,90	0,90	0,31
5					0,00								0,00
	Sum	4	280,00		252,00	= Buvin							
	Samlet specifikt varmetab mod det fri Bt				**450,76**	**= Bt = Bukon+Buvin**							

Konstruktioner mod gulv samt omgivende rum

Nr	Flade	A m^2	U W/m^2K	Br W/K	tr °C	Br*tr W	
1	Sidevægge	700,00	0,30	210,00	22,00	4620,00	
2				0,00		0,00	
3				0,00		0,00	
4				0,00		0,00	
5				0,00		0,00	
	Sum	700		210,00		**4620,00**	**=Σ Br*tr**
	Samlet specifikt varmetab mod omgivende rum Br			**210,00**	**= Br**		

Jordtemperatur for område valgt i "BELA
7,6 °C

Ventilation

	Type	Luftskifte h^{-1}	Rum volum m^3	Luftstrøm m^3/s	Densitet kg/m^3	Varmekap. J/kgK	BL W/K	
1	Ventilation	1,30	6300,00	2,275	1,2	1006	2746,38	
2	Infiltration	0,10	6300,00	0,175	1,2	1006	211,26	
	Sum	1,4		2,450			2957,64	
	Samlet specifikt varmetab ved ventilation BL						**2957,64**	**= BL**

Kontrol
Samlet luftstrøm
liter pr. m^2 gulvareal
3,6

Varmeakkumulering

	Vælg varmeakkumulering	Akk.evne W/K pr m^2	Gulvareal m^2	Ba W/K	
1	Middel let	8	690,00	5520,00	
	Samlet specifik varmeakkumulering Ba			**5520,00**	**= Ba**

Beskrivelse af valgt rumopbygning
Rum med indvendige vægge af letbeton og kun uvæsentlige tunge konstruktionsdele

BELASTNINGER
Gå til ark BELAST

Beregning af belastninger

Projekt:
Grobunden - Atrium
Interne belastninger

Time	Personbelast W	Belysning W	Andet W	Sum W	
1	0	0	100	100	
2	0	0	100	100	
3	0	0	100	100	
4	0	0	100	100	
5	0	0	100	100	
6	0	0	100	100	
7	0	1000	100	1100	
8	1000	500	100	1600	
9	1000	500	100	1600	
10	1300	100	100	1500	
11	1300	100	100	1500	
12	1500	250	100	1850	
13	2000	250	100	2350	
14	3000	250	100	3350	
15	4500	250	100	4850	
16	4500	1000	100	5600	
17	4500	2000	100	6600	
18	4000	2500	100	6600	
19	3500	2500	100	6100	
20	2000	2500	100	4600	
21	1500	2500	100	4100	
22	1000	2500	100	3600	
23	0	0	100	100	
24	0	0	100	100	
Sum	36600	18700	2400	57700	
Middelværdi	1525	779	100	2404	=Φi
Max. timeværdi	4500	2500	100	6600	=Φimax
Min. timeværdi	0	0	100	100	=Φimin

Pr. m² gulvareal	Personbelast W/m²	Belysning W/m²	Andet W/m²	Sum W/m²
Middelværdi	2,21	1,13	0,14	3,48
Max. timeværdi	6,52	3,62	0,14	9,57
Min. timeværdi	0,00	0,00	0,14	0,14

Beregninger
Gå til ark RESULT

Eksterne belastninger

Vælg område
København

Vælg måned
Juli

Udetemperatur: døgnm	21	°C	= tu
variation	12	°C	= Δtu

Solindfald vinduer	Areal m³	Orientering grader	Hældning grader	Fsol [-]	Φs W	Φsmax W
1	110,00	180	90	0,11	2368	7975
2	0,00	180	0	0,31	0	0
3	60,00	180	0	0,31	6225	16666
4	110,00	0	90	0,31	3518	8799
5	0,00	0	0	0,00	0	0
Samlet solindfald i rum					**12111**	**33440**

Hjælp til interne belastninger

Personvarme:	Aktivitet met	Total W/person	Fri varme W/person	Antal pers	Fri i alt W
	1,6	158	96	50	4794

Belysning: almen	Niveau lux	Glødelys W/m² g.a.	Lysstof W/m² g.a.	Lavenergi W/m² g.a.	Vælg effekt W/m² g.a.	Belysning i alt W
	100	26	8	4	4	2760

Særbelysning
Kontorudstyr

Resultater

Projekt:
Grobunden - Atrium

For valgt måned:	**Juli**	tu =	**21**	°C

Hvis ventilationsluften har samme temperatur som udeluften

Døgnmiddeltemperatur	ti =	**25,1**	°C
Temperaturvariation	Δti =	**7,1**	°C
Maksimaltemperatur	timax =	**28,6**	°C

$$t_i = \frac{B_t t_u + \sum B_r t_r + B_L t_L + \Phi_i + \Phi_s}{B_t + \sum B_r + B_L}$$

$$\Delta t_i = t_{imax} - t_{imin} = \frac{\Delta\Phi_K}{B_t + \sum \mathbf{B_r} + B_L + B_{akk}}$$

$$\Delta\Phi_k = \Delta\Phi_{k1} + \Delta\Phi_{k2}$$

$$\Delta\Phi_{k1} = \frac{2}{3}[(\Phi_i + \Phi_s)_{max} - \Phi_{i,min}]$$

$$\Delta\Phi_{k2} = \Delta t_u (B_{u,vin} + B_L)$$

Supplerende beregninger

Hvis ventilationsluften har konstant temperatur lig udeluftens døgnmiddeltemperatur

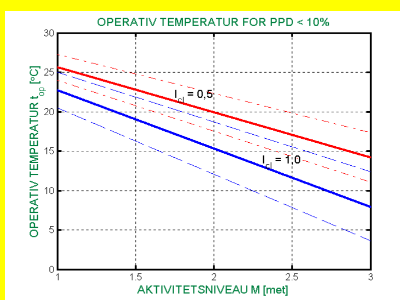
Døgnmiddeltemperatur	ti =	**25,1**	°C
Temperaturvariation	Δti =	**3,5**	°C
Maksimaltemperatur	timax =	**26,8**	°C

Beregning hvor ventilationsluften har konstant indblæsningstemperatur der er Δt = **2** °C lavere end udeluftens døgnmiddeltemperatur

Hvis ventilationsluften har konstant temperatur på **19 °C**

Døgnmiddeltemperatur	ti =	**23,4**	°C
Temperaturvariation	Δti =	**3,5**	°C
Maksimaltemperatur	timax =	**25,2**	°C

Figuren er optegnet på grundlag af regression på tabelværdier i anneks E i DS/ISO 7730.



Appendix 4
Month Average Temperature Estimate: Atrium Open facade

Bygningskarakteristika

Konstruktioner mod det fri

A	Beskrivelse	U	Bu
m^2		W/m^2K	W/K
52	nordvæg	0,11	5,72
0	østvæg	0,09	0
0	vestvæg	0,09	0
124	sydvæg	0,11	13,64
690	gulv	0,13	89,7
685,8	Tag	0,13	89,154
			0
			0
			0
Specifikt varmetab, konstruktioner mod det fri, (W/K)			198,214

= Bu,kon

Vinduer

A	Retning	U	Bu	g-værdi	f(beta)	f(afsk)	f(skyg)	f(glas)	Fsol
m^2		W/m^2K	W/K	[-]	[-]	[-]	[-]	[-]	[-]
110	n	0,9	99	0,48	0,9	0,9	0,6	0,9	0,209952
0	nø	0,9	0	0,48	0,9	0,8	0,9	0,9	0,279936
0	ø	0,9	0	0,48	0,9	0,8	0,9	0,9	0,279936
0	sø	0,9	0	0,48	0,9	0,8	0,9	0,9	0,279936
110	s	0,9	99	0,48	0,9	0,4	0,9	0,9	0,139968
0	sv	0,9	0	0,48	0,9	0,3	0,7	0,9	0,081648
0	v	0,9	0	0,48	0,9	0,8	0,9	0,9	0,279936
0	nv	0,9	0	0,48	0,9	0,8	1	0,9	0,31104
60	ovenlys	0,9	54	0,48	0,9	1	0,8	0,9	0,31104
Specifikt varmetab, vinduer, (W/K)			252	= Bu,vin					

Specifikt varmetab mod det fri, total: (W/K)	450,214	= Bt (=Bu,kon+Bu,vin)

Gulv

A	U	Bu
m^2	W/m^2K	W/K
690	0,13	89,7
		0
		0
		0
		0
Specifikt varmetab, gulv, (W/K)		89,7

= Bu,gulv

Varmekapacitet

Varmekapacitet	80
Tidskonstant	28,7
a	2,8

Ventilation

Ventilationsmængde, sommer

Brugstid, l/s m2	3,30
Udenfor Brugstid, l/s m2	1,50
Middel ventilationsmængde, m3/s	1,60

Månedsmiddelberegning

AALBORG UNIVERSITET

Bygningdata

Rumtemperatur v opvarm, °C	19
Rumtemperatur v køling, °C	24
Jordtemperatur, °C	7,6
Netto areal, m²	690
Brutto areal, m²	690
Opvarmet bebygget areal, m²	690
Normal brugstid, timer/uge	77
Relativt brug	0,458

Vejrdata

Vælg destination

København

Hvis der ikke vises kommentarer aktiveres disse under "Vis"

Bygningens varme- og kølebehov

Måned	Antal dage	Kølebehov	Varmebehov	Ventilationstab	Brugsfaktor	Solindfald	Internt tilskud	Tilskud pga tu>ti	Varmetab v. vintertemp.	Varmetab v. sommertemp.
		kWh/måned	kWh/måned	W/K		kWh	kWh	kWh	kWh	kWh
Jan	31	0	17159	832	0,997	925	1765	0	19841	24945
Feb	28	0	14294	832	0,993	1624	1595	0	17490	22100
Mar	31	0	12606	832	0,982	2786	1765	0	17074	22178
Apr	30	0	7175	832	0,931	4368	1709	0	12830	17769
Maj	31	0	2534	832	0,770	5971	1765	0	8487	13591
Jun	30	0	401	832	0,498	6001	1709	0	4243	9183
Jul	31	0	235	832	0,434	5824	1765	0	3526	8630
Aug	31	0	346	832	0,495	5046	1765	0	3717	8821
Sep	30	0	2244	832	0,814	3356	1709	0	6367	11306
Okt	31	0	6749	832	0,961	2029	1765	0	10395	15499
Nov	30	0	11373	832	0,991	1064	1709	0	14122	19062
Dec	31	0	15730	832	0,997	635	1765	0	18123	23227
SUM		***0***	***90845***			***39629***	***20787***	***0***	***136214***	***196310***

Resultat

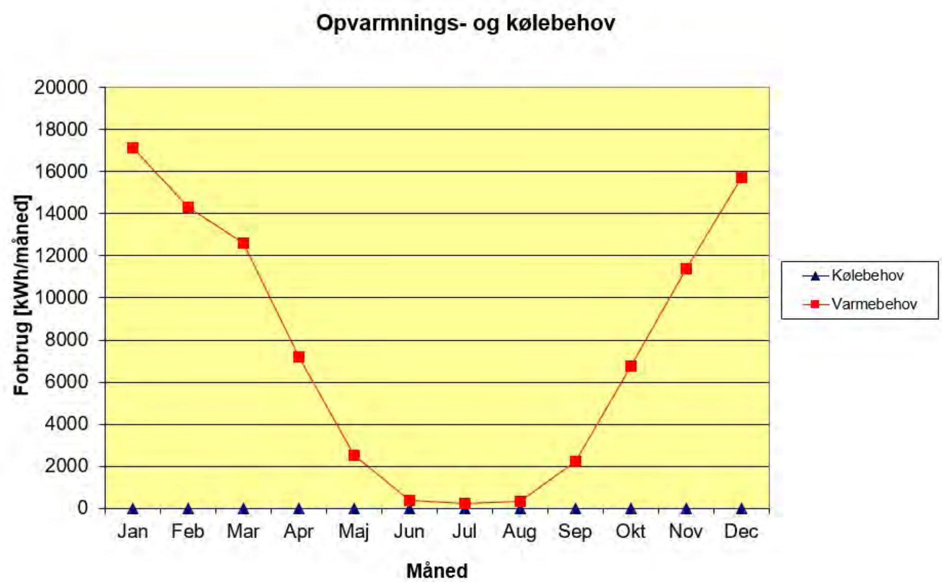
Energiforbrug til opvarmning pr m2 gulvareal, kWh/m2 år	**131,7**
Energiforbrug til køling pr m2 gulvareal,kWh/m2 år	**0,0**
Totalt energiforbrug pr m2 gulvareal, kWh/m2 år	**131,7**

Til sammenligning…

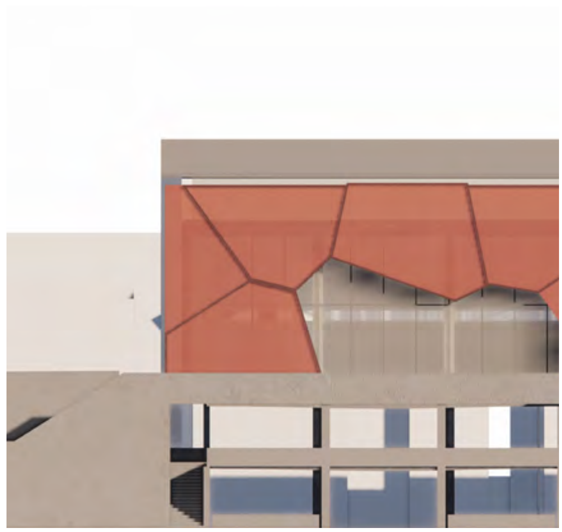
Energirammen for boliger	31,4 kWh/m² år
Klasse 2020	20,0 kWh/m² år

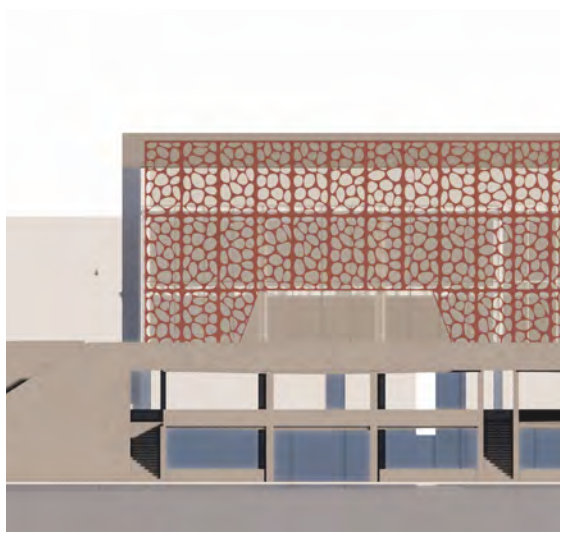
Internt varmetilskud

Time	Personbelast W	Belysning W	Andet W	Sum W
1	0	0	100	100
2	0	0	100	100
3	0	0	100	100
4	0	0	100	100
5	0	0	100	100
6	0	0	100	100
7	0	250	100	350
8	1000	500	100	1600
9	1000	500	100	1600
10	1300	100	100	1500
11	1300	100	100	1500
12	1500	250	100	1850
13	2000	250	100	2350
14	3000	250	100	3350
15	4500	250	100	4850

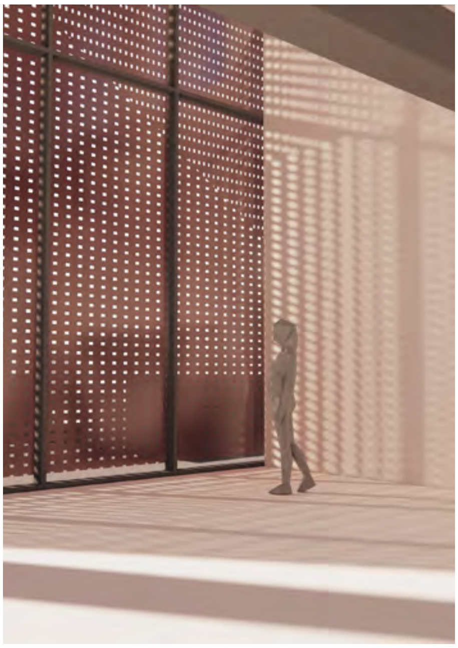


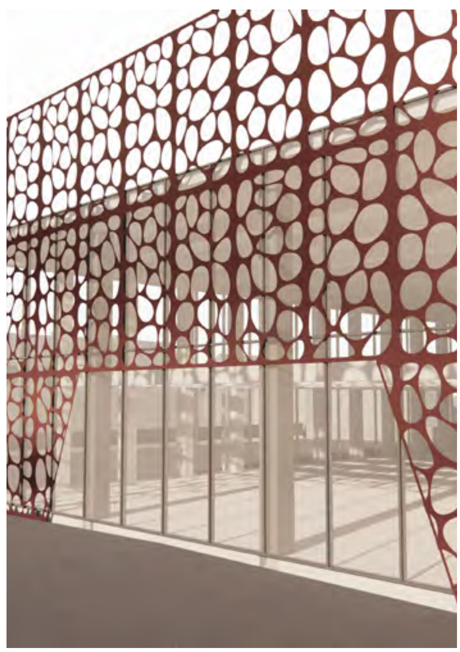
Appendix 5
Facade Expression and Formgiving Iterations





Facade Expression and Formgiving Iterations





Fenestration- 24-hour average estimate: Cafe

Beregning af døgnmiddeltemperatur

med danske vejrdata

AALBORG UNIVERSITET
ARCHITECTURAL ENGINEERING

Projekt:
Grobunden - Cafe

Rumopbygning

Hvis der ikke vises kommentarer aktiveres disse under "Vis"

Konstruktioner mod det fri

Nr	Flade	A m^2	U W/m^2K	Bu W/K	
1	Sydvæg	78,00	0,11	8,58	
2	East	38,00	0,11	4,18	
3	West	13,00	0,11	1,43	
4	Floor		0,13	0,00	
5				0,00	
	Sum	129,00		14,19	= Bukon

Vinduer mod det fri

Nr	Flade	Antal stk	A m^2	U W/m^2K	Bu W/K	Orient grader	Hældning 90/45/0	g-værdi [-]	f(beta) [-]	f(afsk) [-]	f(skyg) [-]	f(glas) [-]	Fsol [-]
1	Syd, vinduer	1	22,00	0,90	19,80	180	90	0,30	0,90	0,70	0,90	0,90	0,15
2	Syd, glass façade	1	50,00	0,90	45,00	180	90	0,30	0,90	0,70	0,60	0,90	0,10
3	East, vinduer	1	22,00	0,90	19,80	90	90	0,30	0,90	0,60	0,90	0,90	0,13
4	East, glass façade	1	10,00	0,90	9,00	90	90	0,30	0,90	0,60	0,80	0,90	0,12
5	West, glass façade	1	5,00	0,90	4,50	270	90	0,30	0,90	0,90	0,90	0,90	0,20
	Sum	5	109,00		98,10	= Buvin							
	Samlet specifikt varmetab mod det fri Bt				**112,29**	**= Bt = Bukon+Buvin**							

Konstruktioner mod gulv samt omgivende rum

Nr	Flade	A m^2	U W/m^2K	Br W/K	tr °C	Br*tr W	
1	East wall	54,00	0,30	16,20	24,00	388,80	
2	North wall	150,00	0,30	45,00	24,00	1080,00	
3	West wall	40,00	0,30	12,00	24,00	288,00	
4	Floor	126,00	0,13	16,38	10,00	163,80	
5	Ceiling	165,00	0,30	49,50	24,00	1188,00	
	Sum	535		139,08		**3108,60**	**=Σ Br*tr**
	Samlet specifikt varmetab mod omgivende rum Br			**139,08**	**= Br**		

Jordtemperatur for område valgt i "BELA
7,6 °C

Ventilation

	Type	Luftskifte h^{-1}	Rum volum m^3	Luftstrøm m^3/s	Densitet kg/m^3	Varmekap. J/kgK	BL W/K	
1	Ventilation	2,00	1000,00	0,556	1,2	1006	670,67	
2	Infiltration	0,10	1000,00	0,028	1,2	1006	33,53	
	Sum	2,1		0,583			704,20	
	Samlet specifikt varmetab ved ventilation BL						**704,20**	**= BL**

Kontrol
Samlet luftstrøm
liter pr. m^2 gulvareal
2,0

Varmeakkumulering

	Vælg varmeakkumulering	Akk.evne W/K pr m^2	Gulvareal m^2	Ba W/K	
1	Middel let	8	290,00	2320,00	
	Samlet specifik varmeakkumulering Ba			**2320,00**	**= Ba**

Beskrivelse af valgt rumopbygning
Rum med indvendige vægge af letbeton og kun uvæsentlige tunge konstruktionsdele

BELASTNINGER

Gå til ark BELAST

Beregning af belastninger

Projekt:
Grobunden - Cafe

Interne belastninger

Time	Personbelast W	Belysning W	Andet W	Sum W	
1	0	0	100	100	
2	0	0	100	100	
3	0	0	100	100	
4	0	0	100	100	
5	0	0	100	100	
6	0	0	100	100	
7	0	0	100	100	
8	0	0	100	100	
9	500	1000	100	1600	
10	500	500	100	1100	
11	1000	100	100	1200	
12	2000	250	100	2350	
13	1500	250	100	1850	
14	2000	250	100	2350	
15	1000	250	100	1350	
16	1000	500	100	1600	
17	1000	500	100	1600	
18	1000	500	100	1600	
19	0	0	100	100	
20	0	0	100	100	
21	0	0	100	100	
22	0	0	100	100	
23	0	0	100	100	
24	0	0	100	100	
Sum	11500	4100	2400	18000	
Middelværdi	479	171	100	750	=Φi
Max. timeværdi	2000	1000	100	2350	=Φimax
Min. timeværdi	0	0	100	100	=Φimin

Pr. m² gulvareal	Personbelast W/m²	Belysning W/m²	Andet W/m²	Sum W/m²
Middelværdi	1,65	0,59	0,34	2,59
Max. timeværdi	6,90	3,45	0,34	8,10
Min. timeværdi	0,00	0,00	0,34	0,34

Beregninger

Gå til ark RESULT

Eksterne belastninger

Vælg område

København

Vælg måned

Juli

Udetemperatur: døgnm	21	°C	= tu
variation	12	°C	= Δtu

Solindfald vinduer	Areal m³	Orientering grader	Hældning grader	Fsol [-]	Φs W	Φsmax W
1	22,00	180	90	0,15	666	2243
2	50,00	180	90	0,10	1009	3399
3	22,00	90	90	0,13	625	2408
4	10,00	90	90	0,12	252	973
5	5,00	270	90	0,20	221	845
Samlet solindfald i rum					2774	9867

Hjælp til interne belastninger

Personvarme:	Aktivitet met	Total W/person	Fri varme W/person	Antal pers	Fri i alt W
	1,0	99	66	30	1989

Belysning: almen	Niveau lux	Glødelys W/m² g.a.	Lysstof W/m² g.a.	Lavenergi W/m² g.a.	Vælg effekt W/m² g.a.	Belysning i alt W
	100	26	8	4	4	1160

Særbelysning
Kontorudstyr

Resultater

Projekt:
Grobunden - Cafe

For valgt måned:	Juli	tu =	21	°C

Hvis ventilationsluften har samme temperatur som udeluften

Døgnmiddeltemperatur	ti =	24,9	°C
Temperaturvariation	Δti =	5,4	°C
Maksimaltemperatur	timax =	27,6	°C

$$t_i = \frac{B_t t_u + \sum B_r t_r + B_L t_L + \mathbf{\Phi_i} + \mathbf{\Phi_s}}{B_t + \sum B_r + B_L}$$

$$\Delta t_i = t_{imax} - t_{imin} = \frac{\Delta\Phi_K}{B_t + \sum \mathbf{B_r} + B_L + B_{akk}}$$

$$\mathbf{\Delta\Phi_k = \Delta\Phi_{k1} + \Delta\Phi_{k2}}$$

$$\mathbf{\Delta\Phi_{k1} = \frac{2}{3}[(\Phi_i + \Phi_s)_{max} - \Phi_{i,min}]}$$

$$\mathbf{\Delta\Phi_{k2} = \Delta t_u (B_{u,vin} + B_L)}$$

Supplerende beregninger

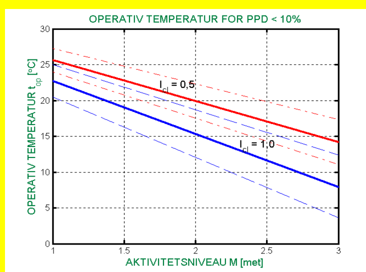
Hvis ventilationsluften har konstant temperatur lig udeluftens døgnmiddeltemperatur

Døgnmiddeltemperatur	ti =	24,9	°C
Temperaturvariation	Δti =	3,0	°C
Maksimaltemperatur	timax =	26,4	°C

Beregning hvor ventilationsluften har konstant indblæsningstemperatur der er Δt = 2 °C lavere end udeluftens døgnmiddeltemperatur

Hvis ventilationsluften har konstant temperatur på 19 °C

Døgnmiddeltemperatur	ti =	23,4	°C
Temperaturvariation	Δti =	3,0	°C
Maksimaltemperatur	timax =	24,9	°C



Figuren er optegnet på grundlag af regression på tabelværdier i anneks E i DS/ISO 7730.

Appendix 7
Fenestration- 24 hour average estimate: Workshop

Beregning af døgnmiddeltemperatur
med danske vejrdata

AALBORG UNIVERSITET
ARCHITECTURAL ENGINEERING

Projekt:
Grobunden - Mushroom workshop

Rumopbygning

Hvis der ikke vises kommentarer aktiveres disse under "Vis"

Konstruktioner mod det fri

Nr	Flade	A m²	U W/m²K	Bu W/K	
1	South	63,00	0,11	6,93	
2	West	26,30	0,11	2,89	
3			0,11	0,00	
4			0,13	0,00	
5				0,00	
	Sum	89,30		9,82	= Bukon

Vinduer mod det fri

Nr	Flade	Antal stk	A m²	U W/m²K	Bu W/K	Orient grader	Hældning 90/45/0	g-værdi [-]	f(beta) [-]	f(afsk) [-]	f(skyg) [-]	f(glas) [-]	Fsol [-]
1	South, windows	1	22,00	0,90	19,80	180	90	0,30	0,90	0,60	0,90	0,90	0,13
2	West, windows	1	3,70	0,90	3,33	270	90	0,30	0,90	0,60	0,80	0,90	0,12
3		1		0,90	0,00	90	90	0,30	0,90	0,60	0,90	0,90	0,13
4		1		0,90	0,00	90	90	0,30	0,90	0,50	0,80	0,90	0,10
5		1		0,90	0,00	270	90	0,30	0,90	0,80	0,90	0,90	0,17
	Sum	5	25,70		23,13	= Buvin							
	Samlet specifikt varmetab mod det fri Bt				32,95	= Bt = Bukon+Buvin							

Konstruktioner mod gulv samt omgivende rum

Nr	Flade	A m²	U W/m²K	Br W/K	tr °C	Br*tr W	
1	East wall	30,00	0,30	9,00	24,00	216,00	
2	North wall	85,00	0,30	25,50	24,00	612,00	
3				0,00	24,00	0,00	
4	Floor	111,00	0,30	33,30	24,00	799,20	
5	Ceiling	111,00	0,30	33,30	24,00	799,20	
	Sum	337		101,10		2426,40	=Σ Br*tr
	Samlet specifikt varmetab mod omgivende rum Br			101,10	= Br		

Jordtemperatur for område valgt i "BEL/
7,6 °C

Ventilation

	Type	Luftskifte h^{-1}	Rum volum m^3	Luftstrøm m^3/s	Densitet kg/m^3	Varmekap. J/kgK	BL W/K	
1	Ventilation	2,00	388,00	0,216	1,2	1006	260,22	
2	Infiltration	0,10	388,00	0,011	1,2	1006	13,01	
	Sum	2,1		0,226			273,23	
	Samlet specifikt varmetab ved ventilation BL						273,23	= BL

Kontrol
Samlet luftstrøm
liter pr. m² gulvareal
2,0

Varmeakkumulering

	Vælg varmeakkumulering	Akk.evne W/K pr m²	Gulvareal m²	Ba W/K	
1	Middel let	8	111,00	888,00	
	Samlet specifik varmeakkumulering Ba			888,00	= Ba

Beskrivelse af valgt rumopbygning
Rum med indvendige vægge af letbeton og kun uvæsentlige tunge konstruktionsdele

BELASTNINGER
Gå til ark BELAST

Beregning af belastninger

Projekt:

Grobunden - Mushroom wor

Interne belastninger

Time	Personbelast W	Belysning W	Andet W	Sum W
1	0	0	100	100
2	0	0	100	100
3	0	0	100	100
4	0	0	100	100
5	0	0	100	100
6	0	0	100	100
7	0	0	100	100
8	1200	300	100	1600
9	1200	300	100	1600
10	0	0	100	100
11	500	100	100	700
12	1200	50	100	1350
13	1200	50	100	1350
14	500	50	100	650
15	1000	50	100	1150
16	128	50	100	278
17	1000	100	100	1200
18	1000	200	100	1300
19	0	0	100	100
20	1200	350	100	1650
21	0	0	100	100
22	0	0	100	100
23	0	0	100	100
24	0	0	100	100
Sum	10128	1600	2400	14128
Middelværdi	422	67	100	589 =Φi
Max. timeværdi	1200	350	100	1650 =Φimax
Min. timeværdi	0	0	100	100 =Φimin

Pr. m^2 gulvareal	Personbelast W/m^2	Belysning W/m^2	Andet W/m^2	Sum W/m^2
Middelværdi	3,80	0,60	0,90	5,30
Max. timeværdi	10,81	3,15	0,90	14,86
Min. timeværdi	0,00	0,00	0,90	0,90

Beregninger

Gå til ark RESULT

Eksterne belastninger

Vælg område

København

Vælg måned

Juli

Udetemperatur: døgnm	21	°C	= tu
variation	12	°C	= Δtu

Solindfald vinduer	Areal m^3	Orientering grader	Hældning grader	Fsol [-]	Φs W	Φsmax W
1	22,00	180	90	0,13	571	1923
2	3,70	270	90	0,12	97	371
3	0,00	90	90	0,13	0	0
4	0,00	90	90	0,10	0	0
5	0,00	270	90	0,17	0	0
Samlet solindfald i rum					**668**	**2293**

Hjælp til interne belastninger

Personvarme:	Aktivitet met	Total W/person	Fri varme W/person	Antal pers	Fri i alt W
	1,3	128	81	15	1216

Belysning: almen	Niveau lux	Glødelys W/m^2 g.a.	Lysstof W/m^2 g.a.	Lavenergi W/m^2 g.a.	Vælg effekt W/m^2 g.a.	Belysning i alt W
	100	26	8	4	4	444

Særbelysning

Kontorudstyr

Resultater

Projekt:

Grobunden - Mushro

For valgt måned:	**Juli**	tu =	21	°C

Hvis ventilationsluften har samme temperatur som udeluften

Døgnmiddeltemperatur	ti =	24,8	°C
Temperaturvariation	Δti =	4,7	°C
Maksimaltemperatur	timax =	27,2	°C

$$t_i = \frac{B_t t_u + \sum B_r t_r + B_L t_L + \Phi_i + \Phi_s}{B_t + \sum B_r + B_L}$$

$$\Delta t_i = t_{imax} - t_{imin} = \frac{\Delta\Phi_K}{B_t + \sum B_r + B_L + B_{akk}}$$

$$\Delta\Phi_k = \Delta\Phi_{k1} + \Delta\Phi_{k2}$$

$$\Delta\Phi_{k1} = \frac{2}{3}[(\Phi_i + \Phi_s)_{max} - \Phi_{i,min}]$$

$$\Delta\Phi_{k2} = \Delta t_u (B_{u,vin} + B_L)$$

Supplerende beregninger

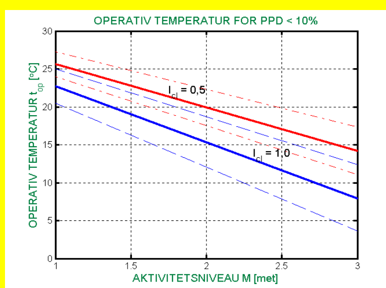
Hvis ventilationsluften har konstant temperatur lig udeluftens døgnmiddeltemperatur

Døgnmiddeltemperatur	ti =	24,8	°C
Temperaturvariation	Δti =	2,3	°C
Maksimaltemperatur	timax =	26,0	°C

Beregning hvor ventilationsluften har konstant indblæsningstemperatur der er Δt = 2 °C lavere end udeluftens døgnmiddeltemperatur

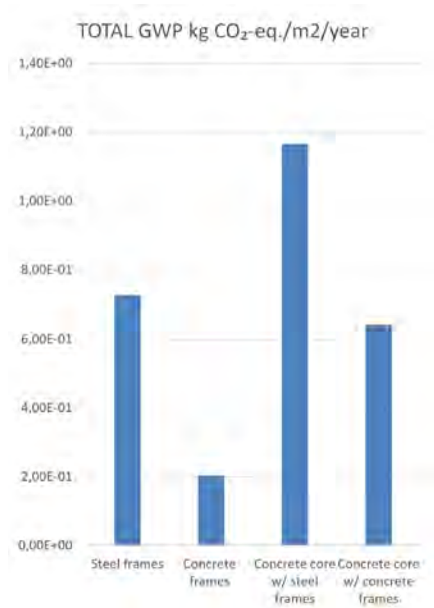
Hvis ventilationsluften har konstant temperatur på 19 °C

Døgnmiddeltemperatur	ti =	23,5	°C
Temperaturvariation	Δti =	2,3	°C
Maksimaltemperatur	timax =	24,7	°C



Figuren er optegnet på grundlag af regression på tabelværdier i anneks E i DS/ISO 7730.

Appendix 8
LCA - LCAbyg data and results - structural systems



Structural system	Building material	Registered amount	Unit	Registered unit	Unit	Calculated amount	Unit	TOTAL GWP	A1-A3	B4	C3	C4	D
								kg CO_2-eq./m2/year	kg CO_2-eq./m2/year				
	Steel beams, IPE 400	685,00	m	65,91	kg/m	45148,35	kg	1,50E-01	1,50E-01	0,00E+00	0,00E+00	1,03E-04	-5,91E-02
Steel frames	Steel columns, HEB 400	1080,00	m	154,44	kg/m	166795,20	kg	5,53E-01	5,53E-01	0,00E+00	0,00E+00	3,79E-04	-2,19E-01
	Fire resistant gympsum boards	1728,00	m²	2,40	m²/m²	4147,20	m²	2,34E-02	2,13E-02	0,00E+00	0,00E+00	2,07E-03	0,00E+00
						TOTAL GWP		7,26E-01					
Concrete frames	Concrete beams, RB 360/960mm	685,00	m	11,09	kg/m	173310,48	kg	8,45E-02	8,31E-02	0,00E+00	1,38E-03	1,73E-05	-1,49E-02
	Concrete columns, 300/300	1080,00	m	9,90	kg/m	243972,00	kg	1,19E-01	1,17E-01	0,00E+00	1,95E-03	2,43E-05	-2,09E-02
						TOTAL GWP		2,04E-01					
	Steel beams, IPE 400	685,00	m	65,91	kg/m	45148,35	kg	1,50E-01	1,50E-01	0,00E+00	0,00E+00	1,03E-04	-5,91E-02
Concrete core w/ steel frames	Steel columns, HEB 400	1080,00	m	154,44	kg/m	166795,20	kg	5,53E-01	5,53E-01	0,00E+00	0,00E+00	3,79E-04	-2,19E-01
	Fire resistant gympsum boards	1728,00	m²	2,40	m²/m²	4147,20	m²	2,34E-02	2,13E-02	0,00E+00	0,00E+00	2,07E-03	0,00E+00
	Concrete core, 400 mm	1238,00	m²	24,00	kg/m²	1218192,00	kg	4,39E-01	4,29E-01	0,00E+00	9,92E-03	6,76E-05	-7,42E-02
						TOTAL GWP		1,17E+00					
	Concrete beams, RB 360/960mm	685,00	m	11,09	kg/m	173310,48	kg	8,45E-02	8,31E-02	0,00E+00	1,38E-03	1,73E-05	-1,49E-02
oncrete core w/ concrete fram	Concrete columns, 300/300	1080,00	m	9,90	kg/m	243972,00	kg	1,19E-01	1,17E-01	0,00E+00	1,95E-03	2,43E-05	-2,09E-02
	Concrete core, 400 mm	1238,00	m²	24,00	kg/m²	1218192,00	kg	4,39E-01	4,29E-01	0,00E+00	9,92E-03	6,76E-05	-7,42E-02
						TOTAL GWP		6,43E-01					

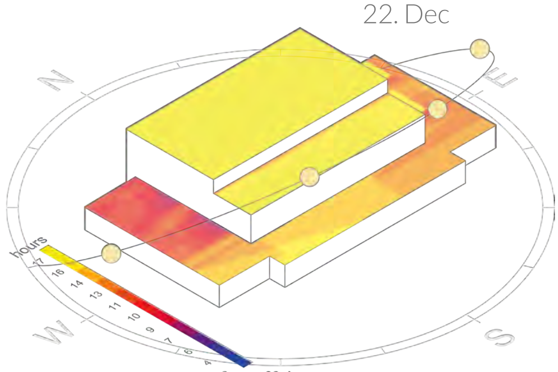
Data from LCAbyg

Appendix 9
Direct Sunlight hours

The following section constitute to simulations done in relations to the urban programming of the outdoor spaces of the new development. The simulation is a direct sun hour calculation, which provides knowledge of how many hours the sun will shine on a defined analysis surface and with surrounding context . the following simulations have been done for four different times in a year using weather data from Denmark to ensure accurate results.

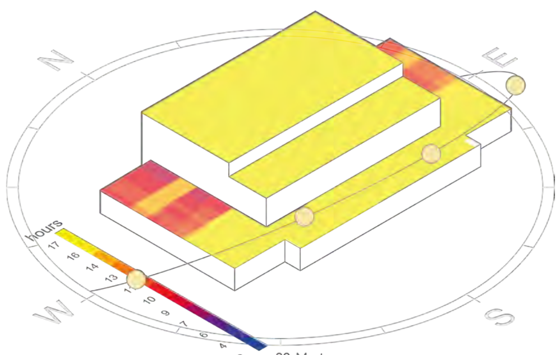
22. Dec

22. June



22. Aug

22. !Aug



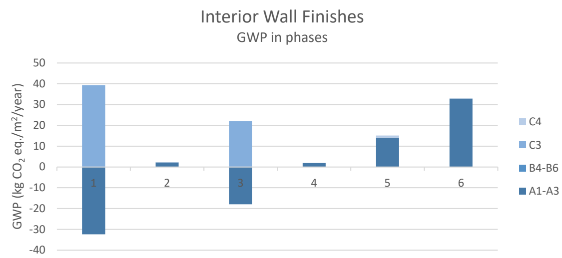
22. Marts

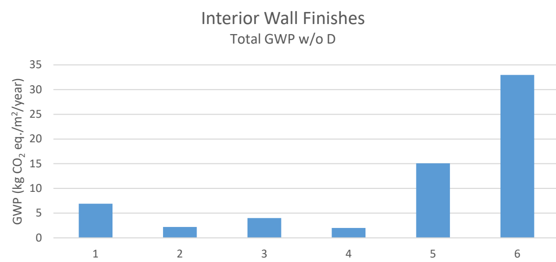
22. Marts

Appendix 10
LCA - Interior Wall Finishes

The materials for the interior wall finishes, which were investigated in the design process are listed below with their properties for GWP as well as thickness. It is possible to see how the materials compare to each others GWP. Here, the glass panels differ from the rest. The glass panels are full structure, whereas the rest depend on a separate construction as the stabilizing element. Therefore, the glass panels have a higher GWP than the rest.

The EPD's used for all calculations are listed in the reference list of all EPD-files.

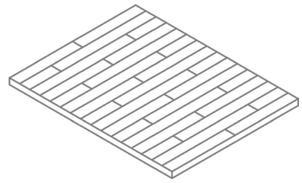




	Wall finishes		GWP	kg CO_2 eq./m^2/year				TOTAL	TOTAL	Thickness	Service life
	Material	Firm	A1-A3	B4-B6	C3	C4	D	(w/o D)	w/ D	(mm)	(years)
1	OSB boards	Norbord	-32,40	0,00	39,30	0,00	-8,67	**6,90**	-1,77	30,0	
2	Mycelium Panels	Knauf Insulation	2,170	0,000	0,000	0,026	-28,10	**2,20**	-25,90	50,00	
3	Plywood	Træ.dk	-17,97	0,00	21,96	0,00	-23,58	**3,99**	-19,59	30,0	
4	Gympsum boards	British Gympsum	1,89	0,00	0,00	0,12	-0,02	**2,01**	1,99	12,5	60
5	Ceramic tiles	TCNA	14,10	0,00	0,00	1,00	0,00	**15,10**	15,10	8	75
6	Glass	Moelven	32,83	0,00	0,00	0,12	-	**32,96**	32,96	75	60

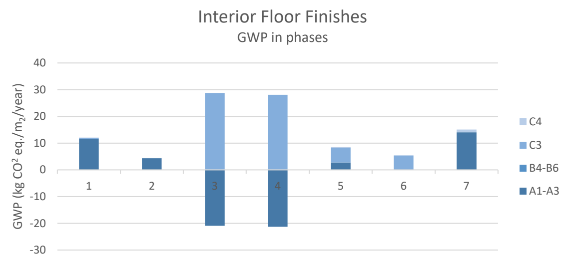
1: OSB board, 2: Mycelium, 3: Plywood, 4: Gypsum board, 5: Tiles, 6: Glass panel

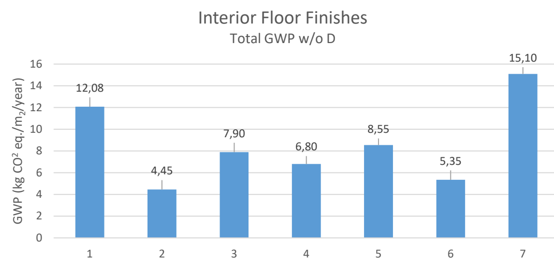
Appendix 11
LCA - Interior Floor Finishes



The materials for the interior floors, which were investigated in the design process are listed below with their properties for GWP as well as thickness. It is possible to see how the materials compare to each others GWP. Here, microcement and linoleum score well because of their thin material thickness, while a material such as wood has a larger GWP.

The EPD's used for all calculations are listed in the reference list of all EPD-files.





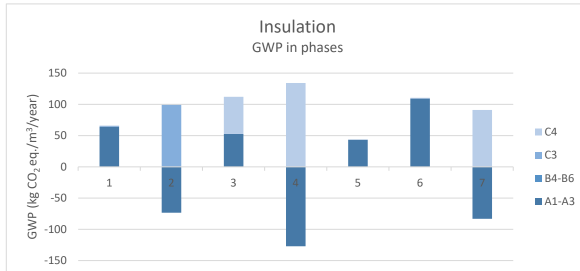
	Floor finishes		GWP	kg CO_2 eq./m^2/year				TOTAL	TOTAL	Thickness	Service life
	Material	Firm	A1-A3	B4-B6	C3	C4	D	(w/o D)	w/ D	(mm)	(years)
1	Concrete	Ikast Betonvarefrabrik	11,50	0,00	0,34	0,25	-0,23	12,08	11,85	50,0	100
2	Microcement coating, Flowcret 1-10 Express	Isomat	4,35	0,00	0,00	0,10	0,00	4,45	4,45	5,0	
3	Solid hardwood, oak, 22 mm, laquer 2	Junckers	-20,90	0,00	28,80	0,00	-7,07	7,90	0,83	22,0	
4	Solid hardwood, beech/ash, 22 mm, laquer 2	Junckers	-21,30	0,00	28,10	0,00	-6,90	6,80	-0,10	22,0	
5	Linoleum, ERFMI	ERFMI	2,78	0,00	5,55	0,22	-1,07	8,55	7,48	2,4	
6	Linoleum, Forbo	Forbo	-0,04	0,00	5,39	0,00	-1,07	5,35	4,28	2,5	150
7	Ceramic tiles	TCNA	14,10	0,00	0,00	1,00	0,00	15,10	15,10	8,0	75

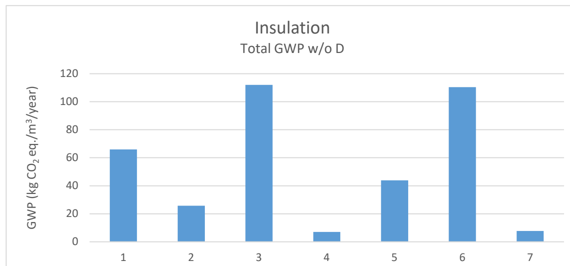
1: Concrete finish, 2: Micro-cement, 3: Solid oak hardwood, 4: Solid beech/ash hardwood, 5: Linoleum ERFMI, 6: Linoleum Forbi, 7: Ceramic tiles

Appendix 12
LCA - Insulation Materials

The materials for insulation are listed in the table with the results of GWP and thermal transmittance. Only three were chosen to further investigate in the design process.

The EPD's used for all calculations are listed in the reference list of all EPD-files.

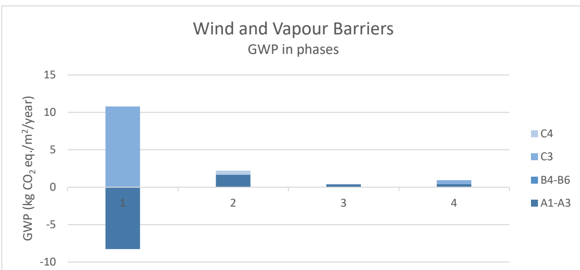


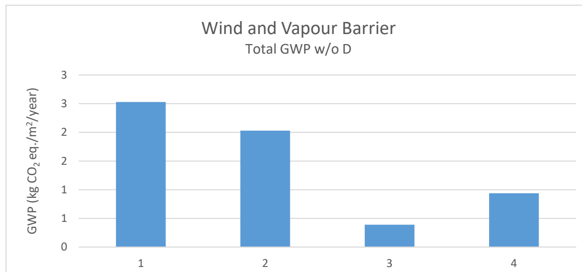


	Insulation		GWP kg CO_2 eq./m^3/year					TOTAL	TOTAL	GWP	U-value
	Material	Firm	A1-A3	B4-B6	C3	C4	D	(w/o D)	w/ D	100 mm	W/mK
1	Mineral wool		64,02	0	1,25	0,69	0,00	65,96	65,96	6,60	0,034
2	Wood fibre	Hunton	-73,37	0	99,08	0,00	-30,51	25,71	-4,80	2,57	0,039
3	EPS Insulation		52,50	0	0	59,50	-31,30	112,00	80,70	11,20	0,035
4	Straw		-127,00	0	0	134,00	0,00	7,00	7,00	0,70	0,065
5	Mineral wool	Knauf Insulation	43,40	0	0	0,52	-28,10	43,92	15,82	4,39	0,032
6	Rock Mineral Wool	Knauf Insulation	109,00	0	0	1,42	-8,49	110,42	101,93	11,04	0,035
7	Cellulose	Isocell	-83,20	0	0	91,00	-6,52	7,80	1,28	0,78	0,039

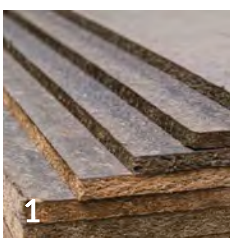
1: Mineral wool, 2: Wood fiber, 3: EPS insulation, 4: Straw, 5: Mineral wool, 6: Rock mineral wool, 7: Cellulose

Appendix 13
LCA - Vapour and Wind Barriers





	Wind barrier		GWP	kg CO_2 eq./m^2/year				TOTAL	TOTAL	sd-value	U-value	Thickness	Service life
	Material	Firm	A1-A3	B4-B6	C3	C4	D	(w/o D)	w/ D	(m)	W/mK	(mm)	(years)
1	Wood fiber barrier	Hunton	-8,25	0	10,78	0,00	-1,67	**2,53**	0,86	0,32	0,05	25,0	60
2	Glass fiber reinforced gypsum plasterboard	Knauf	1,67	0	0,04	0,51	-0,19	**2,03**	2,03	0,63	0,21	9,0	60
	Vapor barrier												
3	RaniMoBar (plastic film)	Ab Rani Plast Oy	0,39	0	0,00	0,00	-0,23	**0,39**	0,16	80		0,2	60
4	Gram vapor barrier	Tommen Gram	0,43	0	0,51	0,00	0,00	**0,94**	0,94	40		0,2	60



1: Wood fibre, 2: Glass fibre, 3: RaniMoBar, 4: Gram vapour barrier

Appendix 14
LCAbyg Data - Initial Building - Results and Amounts

Initial Building - Results
$CO_2/m^2/year$

Description	Name	Total Changes	Total GWP a1_3 kg CO_2-eq.	Total GWP b4 kg CO_2-eq.	Total GWP c3 kg CO_2-eq.	Total GWP c4 kg CO_2-eq.	Total GWP d kg CO_2-eq.	Total GWP sum kg CO_2-eq.
Total	Building		7,30E+00	4,33E-01	6,55E-01	6,39E-02	-1,75E+00	8,45E+00
Sum	Bygningsdel		7,30E+00	4,33E-01	6,55E-01	6,39E-02	-1,75E+00	8,45E+00
Gruppe	Afløb		2,50E-03	0,00E+00	2,75E-02	0,00E+00	-1,35E-02	3,00E-02
Undergruppe	Faldstammer		2,50E-03	0,00E+00	2,75E-02	0,00E+00	-1,35E-02	3,00E-02
Bygningsdel	Drain, default values		2,50E-03	0,00E+00	2,75E-02	0,00E+00	-1,35E-02	3,00E-02
Gruppe	Dæk		1,57E+00	0,00E+00	2,64E-02	3,51E-02	-1,55E-01	1,63E+00
Undergruppe	Etagedæk		1,57E+00	0,00E+00	2,64E-02	3,51E-02	-1,55E-01	1,63E+00
Bygningsdel	Floor slabs		1,20E+00	0,00E+00	2,64E-02	1,88E-03	-1,53E-01	1,23E+00
Bygningsdel	Floors		3,71E-01	0,00E+00	0,00E+00	3,32E-02	-1,61E-03	4,04E-01
Gruppe	Fundamenter		5,11E-02	0,00E+00	1,09E-03	1,11E-05	-1,03E-02	5,22E-02
Undergruppe	Punktfundament		5,11E-02	0,00E+00	1,09E-03	1,11E-05	-1,03E-02	5,22E-02
Bygningsdel	Foundations		5,11E-02	0,00E+00	1,09E-03	1,11E-05	-1,03E-02	5,22E-02
Gruppe	Indervægge		3,13E-01	9,13E-03	1,13E-01	4,35E-03	-3,90E-02	4,40E-01
Undergruppe	Ikke-bærende indervægge		3,13E-01	9,13E-03	1,13E-01	4,35E-03	-3,90E-02	4,40E-01
Bygningsdel	Interior walls		3,13E-01	9,13E-03	1,13E-01	4,35E-03	-3,90E-02	4,40E-01
Gruppe	Søjler og bjælker		2,14E+00	0,00E+00	3,84E-02	4,37E-04	-3,89E-01	2,18E+00
Undergruppe	Bjælker		2,14E+00	0,00E+00	3,84E-02	4,37E-04	-3,89E-01	2,18E+00
Bygningsdel	Structural system		2,14E+00	0,00E+00	3,84E-02	4,37E-04	-3,89E-01	2,18E+00
Gruppe	Tage		1,43E+00	2,15E-01	2,29E-02	1,93E-02	-1,22E-01	1,69E+00
Undergruppe	Tage		1,43E+00	2,15E-01	2,29E-02	1,93E-02	-1,22E-01	1,69E+00
Bygningsdel	Roof		1,43E+00	2,15E-01	2,29E-02	1,93E-02	-1,22E-01	1,69E+00
Gruppe	Vand		6,40E-02	0,00E+00	-3,35E-02	0,00E+00	1,60E-02	3,05E-02
Undergruppe	Varmtvandsbeholder		6,40E-02	0,00E+00	-3,35E-02	0,00E+00	1,60E-02	3,05E-02
Bygningsdel	Water		6,40E-02	0,00E+00	-3,35E-02	0,00E+00	1,60E-02	3,05E-02
Gruppe	Varme		9,37E-01	0,00E+00	1,53E-01	0,00E+00	-4,58E-01	1,09E+00
Undergruppe	Andet (varme)		9,37E-01	0,00E+00	1,53E-01	0,00E+00	-4,58E-01	1,09E+00
Bygningsdel	Heatin, ventilation and cooling		9,37E-01	0,00E+00	1,53E-01	0,00E+00	-4,58E-01	1,09E+00
Gruppe	Vinduer, døre, glasfacader		3,52E-01	1,94E-01	1,41E-02	8,86E-04	-1,54E-01	5,61E-01
Undergruppe	Døre		1,69E-01	8,40E-02	4,54E-03	8,32E-04	-3,40E-02	2,59E-01
Bygningsdel	Windows and doors		1,69E-01	8,40E-02	4,54E-03	8,32E-04	-3,40E-02	2,59E-01
Undergruppe	Glasfacader		1,82E-01	1,10E-01	9,59E-03	5,45E-05	-1,20E-01	3,02E-01
Bygningsdel	Glass facade		1,82E-01	1,10E-01	9,59E-03	5,45E-05	-1,20E-01	3,02E-01
Gruppe	Ydervægge		4,39E-01	1,50E-02	2,92E-01	3,86E-03	-4,30E-01	7,49E-01
Undergruppe	Ydervægge		4,39E-01	1,50E-02	2,92E-01	3,86E-03	-4,30E-01	7,49E-01
Bygningsdel	Exterior walls		4,39E-01	1,50E-02	2,92E-01	3,86E-03	-4,30E-01	7,49E-01

Description	Name	Written Amount	Calculated Amount	Weigth
Sum	Bygningsdel			8850984,37 kg
Gruppe	Afløb			5500,00 kg
Undergruppe	Faldstammer			5500,00 kg
Bygningsdel	Drain, default values			5500,00 kg
Konstruktion	Drain, default values	5500,00 m²		5500,00 kg
Byggevare	Rør, Afløbsrør, PVC (Klon)	1,00 m²/m²	5500,00 m²	5500,00 kg
Gruppe	Dæk			2691745,20 kg
Undergruppe	Etagedæk			2691745,20 kg
Bygningsdel	Floor slabs			2139489,90 kg
Konstruktion	Dæk, betonelement, forspændt huldæk 0,27/12,0	5500,00 m²		2104529,90 kg
Byggevare	Armeringsnet	10,80 kg/m²	59400,00 kg	59400,00 kg
Byggevare	Beton C45/55, fabriksbeton og betonelementer	371,84 kg/m²	852,14 m³	2045129,90 kg
Konstruktion	Ren. Efterisolering af etagedæk mod uopvarmet	2300,00 m²		34960,00 kg
Byggevare	Dampspærre PE (tykkelse 0,0002 m)	0,20 kg/m²	2300,00 m²	460,00 kg
Byggevare	Mineraluld, løsfyld (Klon)	0,30 m³/m²	690,00 m³	34500,00 kg
Bygningsdel	Floors			552255,30 kg
Konstruktion	Gulv, beton slidlag	4600,00 m²		552255,30 kg
Byggevare	Afretningslag, cementbaseret	120,00 kg/m²	552000,00 kg	552000,00 kg
Byggevare	EPS isolering til lofter / gulve og kælderydervæg /	0,00 m³/m²	13,80 m³	255,30 kg
Byggevare	Micro-cement	1,00 m²/m²	3000,00 m²	3000,00 kg
Byggevare	Oak flooring	1,00 m²/m²	1800,00 m²	1800,00 kg
Gruppe	Fundamenter			124004,00 kg
Undergruppe	Punktfundament			124004,00 kg
Bygningsdel	Foundations			124004,00 kg
Konstruktion	Punktfundament, 3-5 etager 400/1000/1000 mm	62,00 stk.		61504,00 kg
Byggevare	Armeringsnet	32,00 kg/stk.	1984,00 kg	1984,00 kg
Byggevare	Beton C35/45, fabriksbeton og betonelementer	0,40 m³/stk.	24,80 m³	59520,00 kg
Konstruktion	Terrændæk, beton, 250 mm	100,00 m²		62500,00 kg
Byggevare	Armeringsnet	25,00 kg/m²	2500,00 kg	2500,00 kg
Byggevare	Beton C25/30, fabriksbeton og betonelementer	0,25 m³/m²	25,00 m³	60000,00 kg
Gruppe	Indervægge			191259,97 kg
Undergruppe	Ikke-bærende indervægge			191259,97 kg
Bygningsdel	Interior walls			191259,97 kg
Konstruktion	Midterdel, træskelet, ikke-bærende, mineraluld	4600,00 m²		25837,97 kg
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0,05 kg/m²	230,00 kg	230,00 kg
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13%	0,01 m³/m²	32,43 m³	17155,47 kg
Byggevare	Mineraluld, alm.	0,07 m³/m²	322,00 m³	8452,50 kg
Byggevare	Gypsum	1,00 m²/m²	2300,00 m²	46000,00 kg
Byggevare	Mycelium	1,00 m²/m²	2300,00 m²	46000,00 kg
Byggevare	Boards	1,00 m²/m²	2300,00 m²	46000,00 kg
Byggevare	Plywood	1,00 m²/m²	2300,00 m²	46000,00 kg
Konstruktion	Vægside, glasvæg	600,00 m²		34368,00 kg
Byggevare	Aluminiumsprofil	0,50 kg/m²	300,00 kg	300,00 kg
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0,05 kg/m²	30,00 kg	30,00 kg
Byggevare	Glas 3 mm	5,67 m²/m²	3402,00 m²	34020,00 kg
Byggevare	Tætningsliste, EPDB, ekstruderet	0,03 kg/m²	18,00 kg	18,00 kg
Konstruktion	Vægside, malerbehandling, silikatmaling,	2300,00 m²		19274,00 kg
Byggevare	Puds, kalk-gips, inde	8,00 kg/m²	20,44 m³	18400,00 kg
Byggevare	Silikatmaling (indendørs)	0,38 kg/m²	874,00 kg	874,00 kg
Konstruktion	Vægside, vådrumsvæg, let væg	4600,00 m²		111780,00 kg
Byggevare	Keramikfliser, glaseret	1,00 m²/m²	4600,00 m²	92000,00 kg
Byggevare	Mørtel, fliseklæber	3,10 kg/m²	14260,00 kg	14260,00 kg
Byggevare	Vandtætningsmembran, flydende	1,20 kg/m²	5520,00 kg	5520,00 kg
Gruppe	Søjler og bjælker			4398633,12 kg
Undergruppe	Bjælker			4398633,12 kg
Bygningsdel	Structural system			4398633,12 kg
Konstruktion	Betonbjælke, RB 420/720 mm	3380,00 m		2565501,12 kg
Byggevare	Armeringsnet	33,26 kg/m	112432,32 kg	112432,32 kg
Byggevare	Beton C45/55, fabriksbeton og betonelementer	0,30 m³/m	1022,11 m³	2453068,80 kg
Konstruktion	Cores, Midterdel, betonelement 400 mm	1298,00 m²		1277232,00 kg
Byggevare	Armeringsnet	24,00 kg/m²	31152,00 kg	31152,00 kg
Byggevare	Beton C30/37, fabriksbeton og betonelementer	0,40 m³/m²	519,20 m³	1246080,00 kg
Konstruktion	Søjler, beton rammesøjle 500/500	1090,00 m		555900,00 kg
Byggevare	Armeringsnet	30,00 kg/m	32700,00 kg	32700,00 kg
Byggevare	Beton C45/55, fabriksbeton og betonelementer	0,20 m³/m	218,00 m³	523200,00 kg
Gruppe	Tage			1265470,88 kg
Undergruppe	Tage			1265470,88 kg
Bygningsdel	Roof			1265470,88 kg
Byggevare	Armeringsnet (Klon)	9,00 kg/m²	14400,00 kg	14400,00 kg
Byggevare	Mineraluld, trykfast til tagsystem	0,40 m³/m²	640,00 m³	92800,00 kg

Appendix 15
LCAbyg Data - Final Building - Results and Amounts

Final Building - Results
$CO_2/m^2/year$

Description	Name	Total Changes	Total GWP a1_3 kg CO_2-eq.	Total GWP b4 kg CO_2-eq.	Total GWP c3 kg CO_2-eq.	Total GWP c4 kg CO_2-eq.	Total GWP d kg CO_2-eq.	Total GWP sum kg CO_2-eq.
Total	Building		4,19E+00	4,24E-01	1,91E+00	1,92E-02	-1,93E+00	6,55E+00
Sum	Bygningsdel		4,19E+00	4,24E-01	1,91E+00	1,92E-02	-1,93E+00	6,55E+00
Gruppe	Afløb		2,50E-03	0,00E+00	2,75E-02	0,00E+00	-1,35E-02	3,00E-02
Undergruppe	Faldstammer		2,50E-03	0,00E+00	2,75E-02	0,00E+00	-1,35E-02	3,00E-02
Bygningsdel	Drain, default values		2,50E-03	0,00E+00	2,75E-02	0,00E+00	-1,35E-02	3,00E-02
Gruppe	Dæk		1,11E+00	0,00E+00	2,15E-01	2,97E-03	-2,00E-01	1,33E+00
Undergruppe	Etagedæk		1,11E+00	0,00E+00	2,15E-01	2,97E-03	-2,00E-01	1,33E+00
Bygningsdel	Floor slabs		1,20E+00	0,00E+00	2,64E-02	1,88E-03	-1,53E-01	1,23E+00
Bygningsdel	Floors		-8,93E-02	0,00E+00	1,89E-01	1,09E-03	-4,63E-02	1,00E-01
Gruppe	Fundamenter		5,11E-02	0,00E+00	1,09E-03	1,11E-05	-1,03E-02	5,22E-02
Undergruppe	Punktfundament		5,11E-02	0,00E+00	1,09E-03	1,11E-05	-1,03E-02	5,22E-02
Bygningsdel	Foundations		5,11E-02	0,00E+00	1,09E-03	1,11E-05	-1,03E-02	5,22E-02
Gruppe	Indervægge		-1,14E-01	0,00E+00	3,42E-01	8,14E-04	-5,05E-01	2,28E-01
Undergruppe	Ikke-bærende indervægge		-1,14E-01	0,00E+00	3,42E-01	8,14E-04	-5,05E-01	2,28E-01
Bygningsdel	Interior walls		-1,14E-01	0,00E+00	3,42E-01	8,14E-04	-5,05E-01	2,28E-01
Gruppe	Søjler og bjælker		2,14E+00	0,00E+00	3,84E-02	4,37E-04	-3,89E-01	2,18E+00
Undergruppe	Bjælker		2,14E+00	0,00E+00	3,84E-02	4,37E-04	-3,89E-01	2,18E+00
Bygningsdel	Structural system		2,14E+00	0,00E+00	3,84E-02	4,37E-04	-3,89E-01	2,18E+00
Gruppe	Tage		1,50E-01	2,15E-01	4,19E-01	1,16E-02	-9,53E-02	7,95E-01
Undergruppe	Tage		1,50E-01	2,15E-01	4,19E-01	1,16E-02	-9,53E-02	7,95E-01
Bygningsdel	Roof		1,50E-01	2,15E-01	4,19E-01	1,16E-02	-9,53E-02	7,95E-01
Gruppe	Vand		6,40E-02	0,00E+00	-3,35E-02	0,00E+00	1,60E-02	3,05E-02
Undergruppe	Varmtvandsbeholder		6,40E-02	0,00E+00	-3,35E-02	0,00E+00	1,60E-02	3,05E-02
Bygningsdel	Water		6,40E-02	0,00E+00	-3,35E-02	0,00E+00	1,60E-02	3,05E-02
Gruppe	Varme		9,37E-01	0,00E+00	1,53E-01	0,00E+00	-4,58E-01	1,09E+00
Undergruppe	Andet (varme)		9,37E-01	0,00E+00	1,53E-01	0,00E+00	-4,58E-01	1,09E+00
Bygningsdel	Heatin, ventilation and cooling		9,37E-01	0,00E+00	1,53E-01	0,00E+00	-4,58E-01	1,09E+00
Gruppe	Vinduer, døre, glasfacader		3,52E-01	1,94E-01	1,41E-02	8,86E-04	-1,54E-01	5,61E-01
Undergruppe	Døre		1,69E-01	8,40E-02	4,54E-03	8,32E-04	-3,40E-02	2,59E-01
Bygningsdel	Windows and doors		1,69E-01	8,40E-02	4,54E-03	8,32E-04	-3,40E-02	2,59E-01
Undergruppe	Glasfacader		1,82E-01	1,10E-01	9,59E-03	5,45E-05	-1,20E-01	3,02E-01
Bygningsdel	Glass facade		1,82E-01	1,10E-01	9,59E-03	5,45E-05	-1,20E-01	3,02E-01
Gruppe	Ydervægge		-5,04E-01	1,50E-02	7,39E-01	2,48E-03	-1,18E-01	2,53E-01
Undergruppe	Ydervægge		-5,04E-01	1,50E-02	7,39E-01	2,48E-03	-1,18E-01	2,53E-01
Bygningsdel	Exterior walls		-5,04E-01	1,50E-02	7,39E-01	2,48E-03	-1,18E-01	2,53E-01

Description	Name	Written Amount	Calculated Amount	Weight
Sum	Bygningsdel			7802794,30 kg
Gruppe	Afløb			5500,00 kg
Undergruppe	Faldstammer			5500,00 kg
Bygningsdel	Drain, default values			5500,00 kg
Konstruktion	Drain, default values	5500,00 m²		5500,00 kg
Byggevare	Rør, Afløbsrør, PVC (Klon)	1,00 m²/m²	5500,00 m²	5500,00 kg
Gruppe	Dæk			2144289,90 kg
Undergruppe	Etagedæk			2144289,90 kg
Bygningsdel	Floor slabs			2139489,90 kg
Konstruktion	Dæk, betonelement, forspændt huldæk 0,27/12,0 m	5500,00 m²		2104529,90 kg
Byggevare	Armeringsnet	10,80 kg/m²	59400,00 kg	59400,00 kg
Byggevare	Beton C45/55, fabriksbeton og betonelementer	371,84 kg/m²	852,14 m³	2045129,90 kg
Konstruktion	Ren. Efterisolering af etagedæk mod uopvarmet	2300,00 m²		34960,00 kg
Byggevare	Dampspærre PE (tykkelse 0,0002 m)	0,20 kg/m²	2300,00 m²	460,00 kg
Byggevare	Mineraluld, løsfyld (Klon)	0,30 m³/m²	690,00 m³	34500,00 kg
Bygningsdel	Floors			4800,00 kg
Byggevare	Afretningslag, cementbaseret	120,00 kg/m²	552000,00 kg	552000,00 kg
Byggevare	EPS isolering til lofter / gulve og kælderydervæg / terrændæk 040	0,00 m³/m²	13,80 m³	255,30 kg
Konstruktion	Micro-cement 5 mm	3000,00 m²		3000,00 kg
Byggevare	Micro-cement	1,00 m²/m²	3000,00 m²	3000,00 kg
Konstruktion	Oak, solid harwood, 22 mm	1800,00 m²		1800,00 kg
Byggevare	Oak flooring	1,00 m²/m²	1800,00 m²	1800,00 kg
Gruppe	Fundamenter			124004,00 kg
Undergruppe	Punktfundament			124004,00 kg
Bygningsdel	Foundations			124004,00 kg
Konstruktion	Punktfundament, 3-5 etager 400/1000/1000 mm (h/b/d)	62,00 stk.		61504,00 kg
Byggevare	Armeringsnet	32,00 kg/stk.	1984,00 kg	1984,00 kg
Byggevare	Beton C35/45, fabriksbeton og betonelementer	0,40 m³/stk.	24,80 m³	59520,00 kg
Konstruktion	Terrændæk, beton, 250 mm	100,00 m²		62500,00 kg
Byggevare	Armeringsnet	25,00 kg/m²	2500,00 kg	2500,00 kg
Byggevare	Beton C25/30, fabriksbeton og betonelementer	0,25 m³/m²	25,00 m³	60000,00 kg
Gruppe	Indervægge			184000,00 kg
Undergruppe	Ikke-bærende indervægge			184000,00 kg
Bygningsdel	Interior walls			184000,00 kg
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0,05 kg/m²	230,00 kg	230,00 kg
Byggevare	Konstruktionstræ, KVH-kvalitet (15% fugt / 13% H2O)	0,01 m³/m²	32,43 m³	17155,47 kg
Byggevare	Mineraluld, alm.	0,07 m³/m²	322,00 m³	8452,50 kg
Konstruktion	NEW_Gypsum Boards	2300,00 m²		46000,00 kg
Byggevare	Gypsum	1,00 m²/m²	2300,00 m²	46000,00 kg
Konstruktion	NEW_Mycelium Panels	2300,00 m²		46000,00 kg
Byggevare	Mycelium	1,00 m²/m²	2300,00 m²	46000,00 kg
Konstruktion	NEW_OSB Boards (Norbord)	2300,00 m²		46000,00 kg
Byggevare	Boards	1,00 m²/m²	2300,00 m²	46000,00 kg
Konstruktion	NEW_Plywood Boards	2300,00 m²		46000,00 kg
Byggevare	Plywood	1,00 m²/m²	2300,00 m²	46000,00 kg
Byggevare	Aluminiumsprofil	0,50 kg/m²	300,00 kg	300,00 kg
Byggevare	Fastgørelsesmidler/skruer i galvaniseret stål	0,05 kg/m²	30,00 kg	30,00 kg
Byggevare	Glas 3 mm	5,67 m²/m²	3402,00 m²	34020,00 kg
Byggevare	Tætningsliste, EPDB, ekstruderet	0,03 kg/m²	18,00 kg	18,00 kg
Byggevare	Puds, kalk-gips, inde	8,00 kg/m²	20,44 m³	18400,00 kg
Byggevare	Silikatmaling (indendørs)	0,38 kg/m²	874,00 kg	874,00 kg
Byggevare	Keramikfliser, glaseret	1,00 m²/m²	4600,00 m²	92000,00 kg
Byggevare	Mørtel, fliseklæber	3,10 kg/m²	14260,00 kg	14260,00 kg
Byggevare	Vandtætningsmembran, flydende	1,20 kg/m²	5520,00 kg	5520,00 kg
Gruppe	Søjler og bjælker			4398633,12 kg
Undergruppe	Bjælker			4398633,12 kg
Bygningsdel	Structural system			4398633,12 kg
Konstruktion	Betonbjælke, RB 420/720 mm	3380,00 m		2565501,12 kg
Byggevare	Armeringsnet	33,26 kg/m	112432,32 kg	112432,32 kg
Byggevare	Beton C45/55, fabriksbeton og betonelementer	0,30 m³/m	1022,11 m³	2453068,80 kg
Konstruktion	Cores, Midterdel, betonelement 400 mm	1298,00 m²		1277232,00 kg
Byggevare	Armeringsnet	24,00 kg/m²	31152,00 kg	31152,00 kg
Byggevare	Beton C30/37, fabriksbeton og betonelementer	0,40 m³/m²	519,20 m³	1246080,00 kg
Konstruktion	Søjler, beton rammesøjle 500/500	1090,00 m		555900,00 kg

GROBUNDEN

AN URBAN CULTIVATION CENTER

Karoline Petersen
Kasper Brøndum Kristoffersen
Pernille Løkke

Aalborg University
Sustainable Architecture and Tectonics
MSc04 – Group 22