PART 01

Master Thesis 2021

Aalborg University

Overby Bakke Kindergarten

57°05'10.3"N 10°05'09.7"E

Ida-Katrine Arend Grün Hansen

TITLE

Aalborg University
Master in Architecture

Department
Architecture, Design and Media Technology

Semester MSc04
Master Thesis - Overby Bakke Kindergarten
01.02.2021 - 15.06.2021

Group 16

Submission 27.05.2021

Supervisor
Tenna Doktor Olsen Tvedebrink

Part
1/3 - Problem- and analyse phase

Pages
100

Ida-Katrine Arend Grün Hansen

ABSTRACT

This report documents the MSc04 Master Thesis project of Ida-Katrine Arend Grün Hansen, group 16. The project proposes a sustainable kindergarten placed in Overby Bakke, a new developing area of Aalborg municipality, placed in Stae. The city of Stae currently houses about 400 citizens. Additionally, 37 single-family houses as well as 16 senior houses are planned to be built as what is to be Overby Bakke.

As a result of the integrated design process the kindergarten is evolving around both architectural- and engineering methods. The architecture is designed through theory of affordances which promote child development, with the mindset of ensuring child lead play. Furthermore, the building focuses on sustainable strategies ensuring a healthy indoor environment for the occupants, considering the life cycle of the building, and decreases energy consumption as well as CO2 emissions, while improving the architectural value of the space, ensuring integrated design.
The building unifies the children, Overby Bakke's local community, sustainability, and farming as one entity.

Institutions are one of Denmark's most expensive buildings to construct and operate. At the same time studies shows more than 50% of buildings are unoccupied during occupied hours – why it is crucial to consider both efficient construction methods as well as implementing solutions to improve the operation and occupation schedule of the building.
The outcome of the project resulted in a zero-energy building, achieved by passive and active strategies, which is justified in sustaining the everyday life of a kindergarten for both primary and secondary users. Design decisions are justified through a holistic approach of theory and investigations of architectural quality, wellbeing, user comfort and sustainability.

The documentation of Overby Bakke kindergarten is based on the integrated design process, divided into three sections. First the problem- and analysis phase which creates the foundation of the project through research and field study. Second, the sketching- and synthesis phase documenting the design process. Lastly, the presentation phase which is based on the prior phases.

READER'S GUIDE

This report is structured by the integrated design process, divided into three parts: **01** Problem- and analysis, **02** sketching- and synthesis, and **03** presentation. This is part **01** representing the problem- and analysis phase of the project.

The problem phase introduces the project and the problem, which the building aims solve. Whereas the analysis phase makes the foundation for the design criteria, through gathering of data.

CONTENT

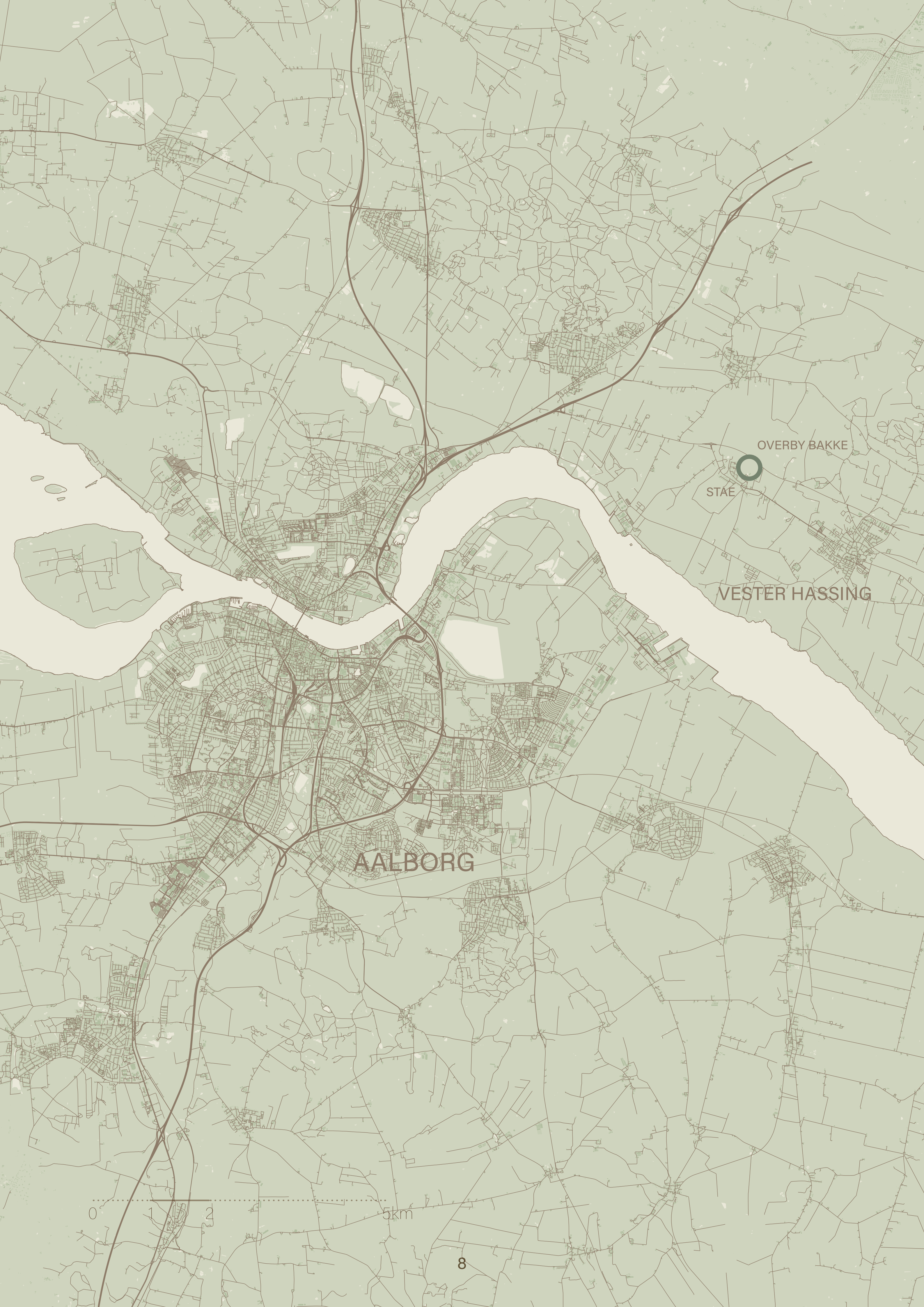
Part 03

Part 02

Part 01

PROLOGUE

Situation map
Introduction
Problem statement
Field of study
Methodology


OVERBY BAKKE
STAE
VESTER HASSING
AALBORG
0
1
2
5km

SITUATION MAP 1:75.000

Ill. 1. 1 : 75.000 Map of area around Overby Bakke

INTRODUCTION

This master thesis covers the design development of a kindergarten placed at Overby Bakke, one of the developing areas of Aalborg Kommune. Overby Bakke is situated in the suburbs of Aalborg in a small city, Stae, with only 395 citizens *(Aalborg Kommune, 2009)*. Stae is a part of the local community of the neighboring city, Vester Hassing *(Aalborg Kommune, 2018)*. The area is surrounded by fields and nature which provides possibilities to create a kindergarten with nature in focus that make children able to develop through endless types of play.

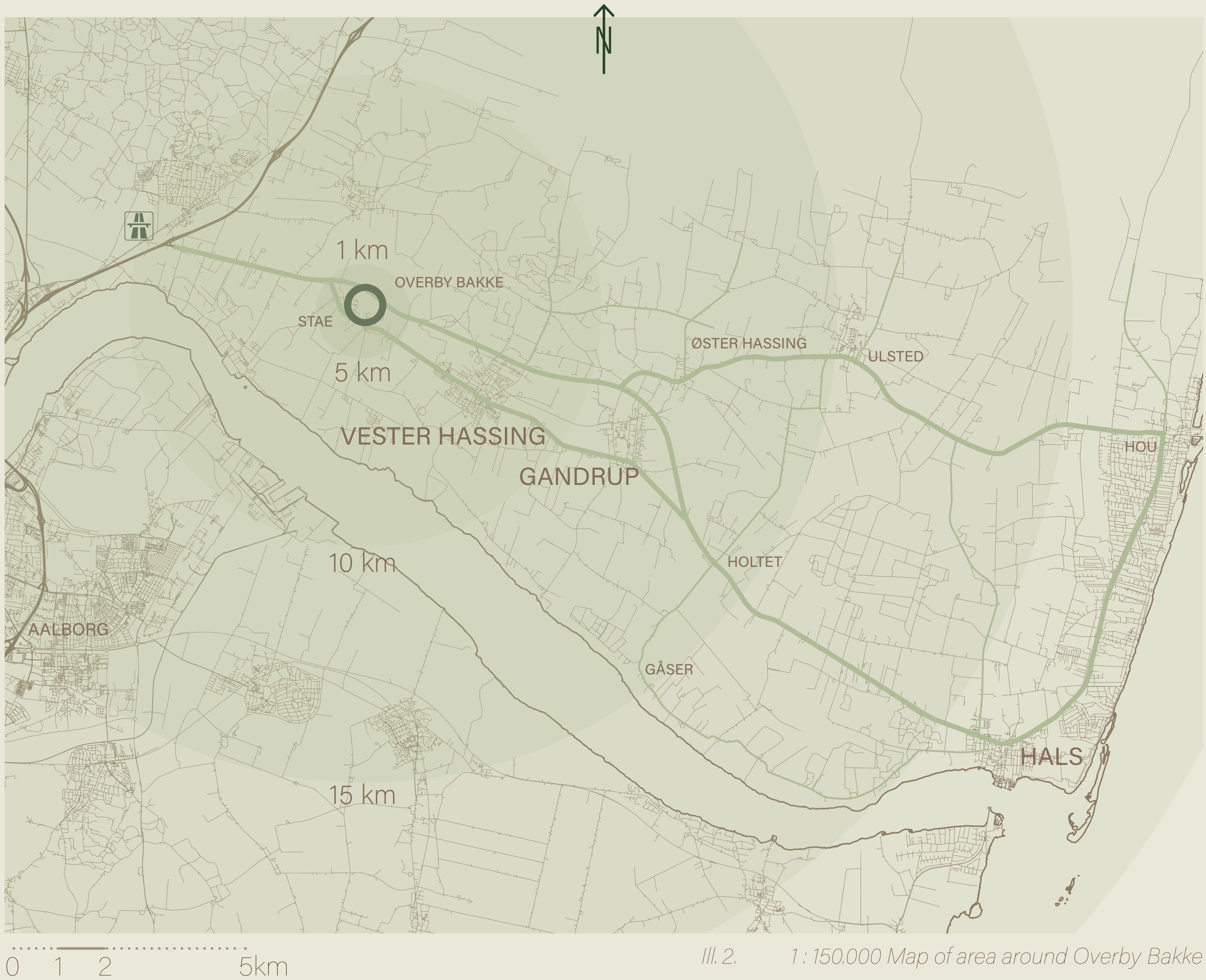
Overby Bakke is currently under construction and is supposed to have 37 single family houses and 16 low-rise high-density houses which is suited for a senior community.

Placing a kindergarten in Overby Bakke is not only beneficial for the local community and the children's developmental purpose, but also for the parents east of Stae.

An investigation of the population shows about 322 children in the age of 3-5 years live in this area of which only 191 of them attend the kindergarten of their own city. It results in 131 children in this area who attend kindergarten away from their home city. This number includes children who live outside a city in the country site.

Additionally, 81 children live more than 5 km from their institution, where 58 of them live further than 10 km away, which means they must be transported by car. Studies show around half of the children do have at least one parent who travels to Aalborg by car daily for work *(Aalborg Kommune, 2016)* why it is relevant to consider that Overby Bakke is placed right where the two main routes to the highway goes.

The key point is, to create a kindergarten that is attractive to those families who make daily commutes to Aalborg. These families must also consider sustainability, outdoor quality and the development of their child, when choosing an appropriate institution.



Ill. 2. 1 : 150.000 Map of area around Overby Bakke

PROBLEM STATEMENT

The kindergarten is a space to improve child development from an early age but what is a good kindergarten and how can the build environment promote a holistic development that supports creativity, play and learning?

1. What is a good kindergarten from an architectural-engineering point of view?

2. How can the build environment promote child development?

3. How can the build environment encourage learning through play?

4. How can the local community support sustainable strategies for both the occupants as well as the building?

FIELD OF STUDY

The field of study in this project is child development, sustainability, and the well-being for the occupants. The driving forces for the building involve implementation of sustainable strategies and the design of a healthy learning environment which initiate play and invite the children to engage with the build environment.

With 25.000 m2 of land the kindergarten will facilitate around 50 children as well as including the local community. The target is to reach a zero-energy building with the goal to fulfil chosen DGNB-criteria. This will be achieved with a focus on the building's energy performance by implementing passive and active strategies – why knowledge of the microclimate is important.

Furthermore, the building will be designed with an awareness on the indoor environment unfolding the comfort of the occupants which include visual-, thermal-, atmospheric-, and acoustic comfort.

The project aims to exploit the opportunities of the future building and the existing area surrounding the kindergarten. To do so, the project will investigate the microclimate, the nature, and the local community. Especially the senior community could be used as a benefit for the kindergarten along with the nature surrounding the area, which will give the children the atmosphere and space to enjoy and learn about the nature.

METHODOLOGY

This report is based on the integrated design process which evolve from the integration of architectural and engineering methods involved in an early stage of a project. This makes it possible to achieve a holistic approach towards sustainability while designing *(Knudstrup, 2005)*. The Integrated Design process has five different phases and it is defined as an iterative process which means it is not chronological, even though it is presented that way:

The problem phase defines the project outlines.

The analysis phase involves data gathering, knowledge, analysis and studies which are to find relevant for the project.

The sketching phase gathers the information from the previous phases to achieve a suitable solution that involve both architectural and engineering methods towards a sustainable achievement.

In **the synthesis phase** previous phases will be further detailed and evaluated according to calculations or simulations.

Last, **the presentation phase** will highlight the results of the project and how the problem is going to be solved *(ibid)*.

Problem phase

Project development

The problem outlines will be developed during the problem phase. Furthermore, the theme of the project will be selected, researched, and investigated with the result of a problem definition which defines the boundaries and focus point of the project.

Research theory

The research will be gathered through books and research papers to give strong evidence-based knowledge to give insight on how it is possible to solve the problem.

Analysis phase

Mapping

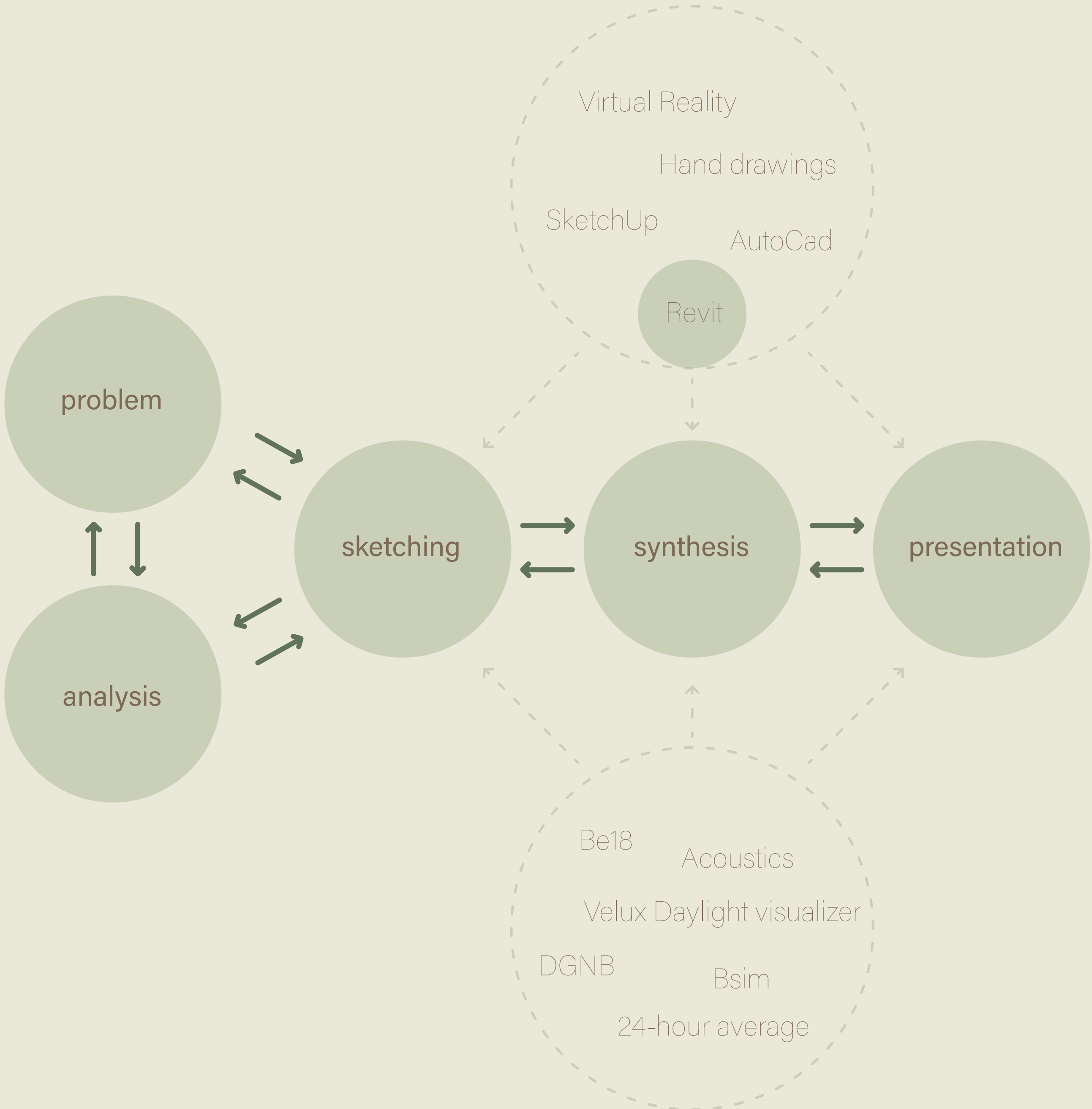
Mapping will be conducted as both desktop analysis and field studies. Analysis involving empirical data will be conducted as desktop study whereas analysis based on emotional- or experience-based knowledge will be conducted as field studies. Methods and tools such as observations, hand drawings, CAD-drawings and notes will be used.

Empirical data

Empirical data will be conducted to give awareness of the building site and the target user group. The data will be gathered through both qualitative and quantitative methods to give a coherent set of data. Methods such as interviews, survey and observations will be used.

Reference studies

Reference studies will be conducted as both pre-studies, information boards and mood boards with a benefit of gathering the data and theory with the practice of real projects. The references also act as a brainstorm tool to transition between the late analysis phase and the early sketching phase.



Ill. 3. The integrated design process

Sketching phase

Tools and methods

Analogue

Hand sketches will be utilized for 2D concept development in the early stage of the sketching process. Moving towards 3D will volumetrically model studies be utilized as a method to understand the site and integrate the concept. 3D sketching is easier to interpret but takes longer time than 2D drawings why it is relevant to evaluate when to utilize which method.

Digital

In the early sketching phase with tools such as inspiration boards and SketchUp to develop concepts and volume studies. Revit and Enscape/Virtual Reality will be utilized during the sketching phase and be a connector to the synthesis phase.

Synthesis phase

Virtual Reality

Virtual Reality is a way to use the sense of vision to percept a building environment. Furthermore, clashes and problems within the design will be detected in the BIM-model. Going from 2D to 3D to 4D in the design process makes it possible to resolve additional problems before the building is constructed.

Simulation tools

Tools as Bsim and Velux daylight visualizer will be utilized to achieve a sustainable design. It will be used to evaluate and improve design decisions according to indoor climate.

Calculation tools

Calculations such as 24-hour average, Be18 and reverberation calculations will be conducted to improve the design during the sketching phase and as a tool to justify decisions.

It is important for both the simulations and calculations to encounter the microclimate analysis to ensure the results are based on valid data.

These calculation tool, as well as Virtual reality, will act as a connector between sketching and synthesis phase when evaluating design iterations.

Presentation phase

Illustrations

Illustration materials made with Adobe-software is important to achieve a holistic presentation of the building. The design of illustrations must be consistent to help the reader understand the building without misunderstandings.

Models

Models will be made to present how the design is situated. It will be used as a visualization tool of the reality.

Academic report

The report is made for the reader to understand the process of the design of the kindergarten. The process will be presented in a reader friendly order to make sure all important decisions are explained.

Part 03

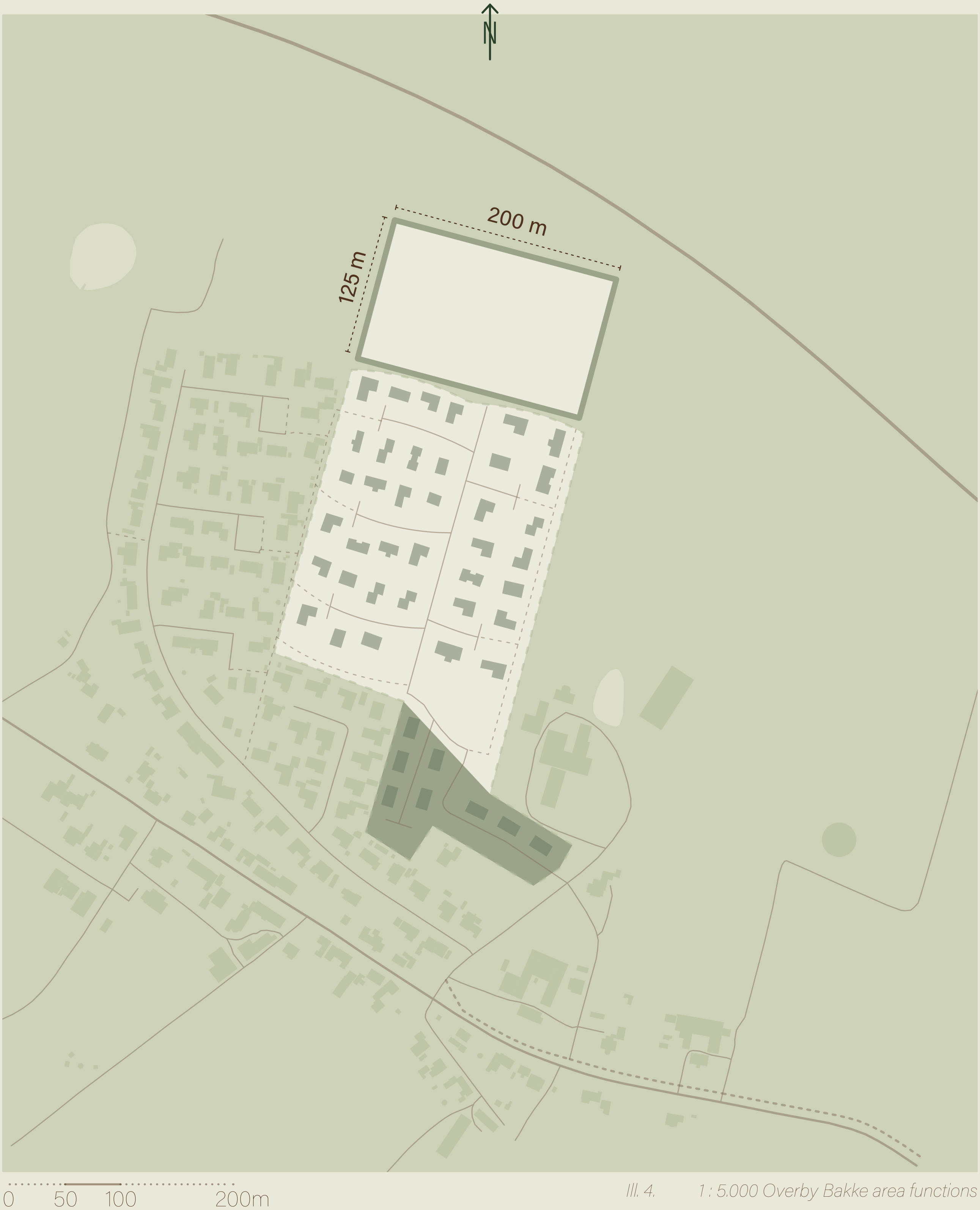
Part 02

Part 01

PROBLEM PHASE

Stae: Overby Bakke
More and better for less
Children's development through play in the build environment
Benefits of farming
Objectives

STAE: OVERBY BAKKE



Ill. 4. 1 : 5.000 Overby Bakke area functions

Existing area
Single family houses
Senior community
Kindergarten

MORE AND BETTER FOR LESS

Flexible and multi-functional buildings have been on many architects radar the last years in order to achieve sustainable design while considering the life span and life cycle of the building. The ability to change a building according to the demands of any occasion has a great purpose. But why not take it up a notch and utilize the existing framework to achieve a multi-purpose building?
Study based on school design shows more than 50% of all rooms are empty within the peak hours of use at 08.00-14.00 *(Antorini. et al. 2017)*. This percentage is increasing after 14.00. Operation of a building is one of the most expensive and least environmentally friendly elements of a building. The building must be operated all day on a regular basis to ensure a healthy indoor environment for the users. This results in a great amount of waste energy provided to operate empty rooms.

Rooms are never neutral; they are always designed with a purpose *(ibid)*. When considering the goals to the users of the building it is possible to not only design a multi-functional building but also multi-purpose building where several users can benefit from shared facilities.

How can this be achieved in the kindergarten?

It is first important to consider the goal for the children in the kindergarten. The main goal is to achieve holistic development for the children in a build environment that encourages skill development through play.
It is possible to go in to depth with different types of children development and investigate the local community to check for organizations, people or institutions which have a potential to benefit the children and the other way around.

Senior community

Many examples such as children visiting senior homes and projects for supplementary grandchildren proves that children and seniors benefit from each other - why it is relevant to consider the development of the senior community in connection with the kindergarten at Overby Bakke.
Sharing the kindergarten with the seniors is both social, environmental, and economically sustainable *(ibid)*. The children will learn how to act around older generations and benefit from their knowledge. Additionally, it decreases loneliness and inactiveness amongst seniors *(Kristen Hicks, 2015)*.

Expensive rooms such as kitchen, common rooms and educational rooms will be used in all hours of the day which prevents waste energy while operating the building. During regular opening hours, the seniors will be able to help the teachers, by caring for potential animals or maintaining crops. This has the potential to improve the community whilst providing a mutual benefit for both the kindergarten, teachers and children.
The seniors will still be able to utilize the building outside the kindergartens regular opening hours.

CHILDREN'S DEVELOPMENT THROUGH PLAY IN THE BUILD ENVIRONMENT

It is crucial to understand how children perceive the build environment while designing a kindergarten which supports the development of the child. This chapter focuses on which types of play in the build environment increase different skills and development.

Focusing on the child directed types of play ensures the children's views are taken into consideration while maintaining the playfulness of learning. The creative play happens through child lead activities. *(Andrea Jelic et al. 2020).*

Theoretically there are three types of child directed plays: **free play**, which is directed and initiated by the child itself with no initial learning goal. **Guided play**, which is directed by the child but initiated by the adult with a learning goal based on exploration and development. Lastly, **game play**, which is designed by an adult but lead by the child usually with an educational goal. *(ibid.)*

In order to be a life-long learner, it is important for a child, early on in their life to develop five different categories of skills *(ibid.)*:

Physical skills
improve motor skills

Social skills
improve communication and collaboration

Emotional skills
improve confidence and motivation

Cognitive skills
improve decision making and problem solving

Creative skills
improve creativity and divergent thinking

These skills can be developed through specific kinds of play in the categories of exercise, sensor motion, symbolic play, sociodramatic and teamwork and sharing. Not all types of play can be supported by the architecture *(ibid)*. Design elements for this project will encourage the possibility of these certain types of play *(see ill. 6)*.

Furthermore, there should be a possibility for the children to explore their curiosity through **risky play** which stimulates the child in relation to their environment, possibilities, and boundaries. Risky play allows the child to develop an awareness for their body while giving them new skills. It changes the child's curiosity towards something that makes the child engage actively and creatively with architectural spaces. Studies show that risky play increases physical activities, social interaction, creativity, and resilience for the child *(ibid)*.

1. Exercise

- physical play
- tumble play

Design elements based on risky play

1. Great heights
- climbing
- jumping

2. Play with speed
- sliding
- swinging

3. Dangerous tools
- using an axe
- using a saw

4. Dangerous elements
- play by water
- play by fire

5. Tumble play
- fencing
- rough play

6. Unknow areas
- ability to hide
- get lost

Ill. 5. Risky play

Design elements play based on development

2. Sensormotion
- play with objects
- touch materials

3. Symbolic play
- drawing
- Writing / reading
- music

4. Sociodramatic
- pretended play
- fiction

5. Teamwork and sharing
- play with rules
- Controled games

Ill. 6. Play based child development

In addition ten design elements must be included in the kindergarten to ensure a holistic approach to a broad range of play which support the development of the child. Each design element invites a different type of play which is meaningful and supportive to the development and needs of different children *(ibid)*.

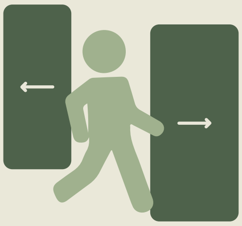
Furthermore, the elements should be designed with the possibility for the child to manage them independently. This makes supervision easier for the teacher and the child has the option of free mobility with a sense of no supervision which increases the child's development, physical health, and wellbeing *(ibid)*.
Active and physical play is lead by the child's independent mobility in the local community which furthermore improves the development of special- and motor skills, social competences, navigation of risky situations, increasing physical activity and the child experience a stronger sense of community and social attachment *(ibid)*.

Design elements based on Heft's preliminary functional taxonomy

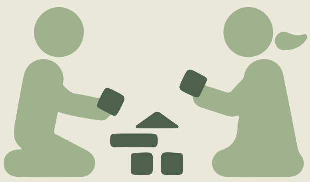
1. Flat smooth surface
Affords walking and running improving physical skills

2. Smooth slope
Affords rolling or sliding as well as rolling opjects

6. Climbable features
Affords exercise and mastery which supports self-esteem and stimulation



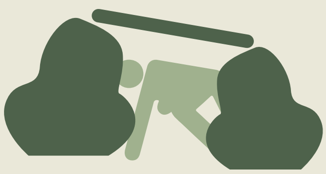
7. Aperture
Affords movement from one place to another



3. Graspable and detached objects
Affords creative and symbolic play such as drawing and constructing which improve sensormotion

4. Attached objects
Affords jumping over, from, on, or down- and hiding behind or inside the objects

5. Non ridget attached objects
Affords swinging and spinning



8. Shelter
Affords prospect, refuge and privacy with qualities to hide and getting lost

9. Moldable material
Materials such as sand affords sculpting and constructing which supports creativity and pretended play

10. Water
Affords splashing, pouring, and mixing as well as swimming

Ill. 7. *Heft's preliminary functional taxonomy*

BENEFITS OF FARMING

1. Intergenerational

Farming qualities and shared facilities intergrates the children, their parents, the teachers and the seniors by having a shared responsability

2. Emotional skills

Children gain emotional skills by being around pets and animals

3. Learning facilities

Farming facilities act as an educational tool for the children to gain learning skills

4. Decreasing obesity

Farming can be a tool to fight obesity for children by having a healthy relationship towards food and the food supply

*Ill. 8.	Four benefits of farming*

Benefits of farming exploiting farming facilities

Ill. 9. Exploitment of farming facilities

Lifecycle of farming exploiting farming facilities

Ill. 10. Exploitment of farming facilities lifecycle

OBJECTIVES

Occupants

1. Implement play

Implement opontunities for play which support the children's developmental needs.

2. Integration of generations

Make sure the local community in Overby Bakke as well as the parents, teachers and children can benefit from each other.

Atmophere

Ill. 11. Icons of objectives

3. Farming | animal

Utilize animals with educational and sustainable purpose and as a tool to develop childrens emotional skills.

4. Farming | gardening

Implementing gardening as a tool towards a sustainable kindergarten with self-sufficient qualities which function as an educational value for the children.

Part 03

Part 02

Part 01

ANALYSIS PHASE / SITE

Site photo
Pattern of use
Microclimate
Topography
Atmosphere

SITE PHOTO

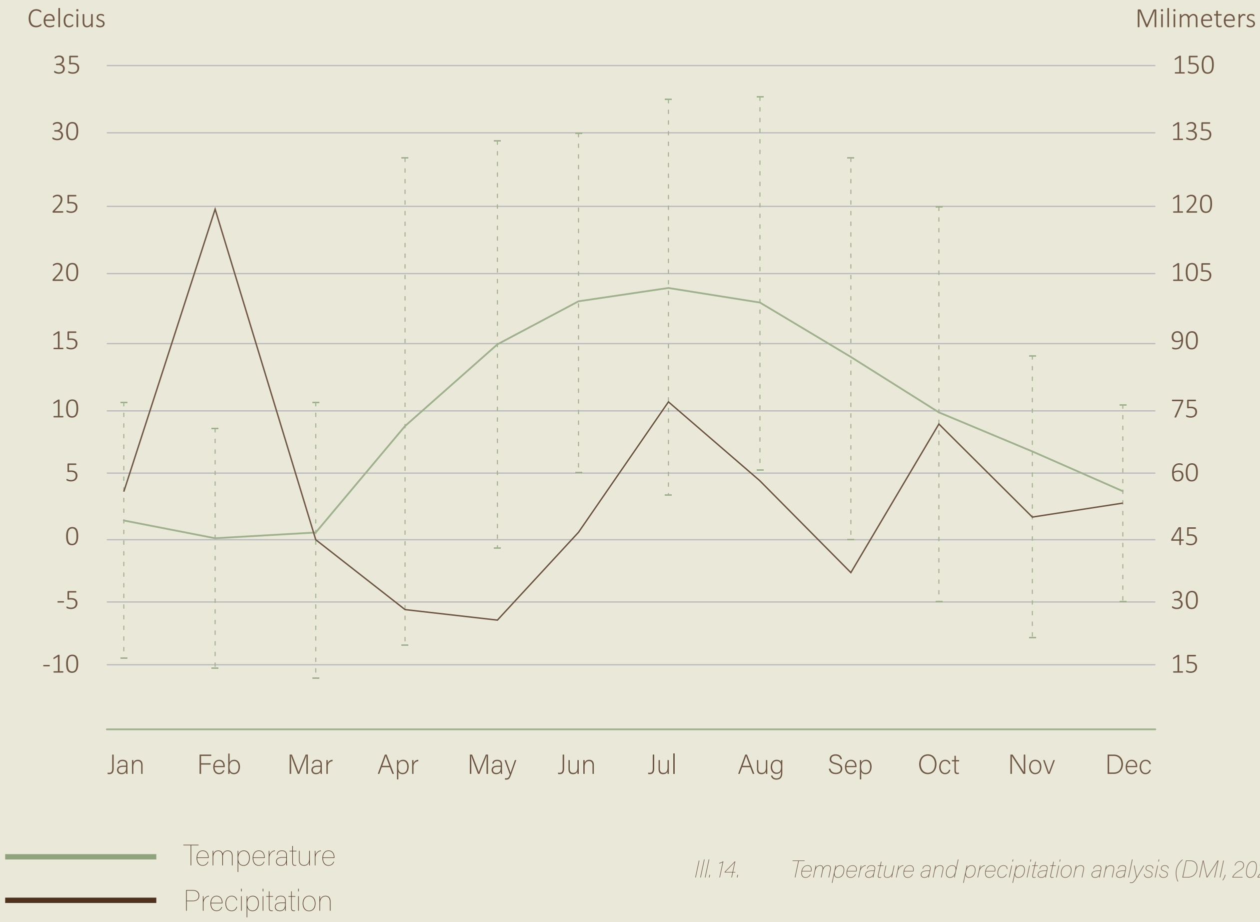
Ill. 12. Drone photo of Overby Bakke

Ill. 13. 1 : 150.000 Mapping, pattern of use

PATTERN OF USE

Stae is mainly recognized as a residential area with a great majority of single-family houses. Citizens of Stae depend on other nearby cities to get groceries, children institutions and more. A townhall is placed within the city which is usually used as private rental for parties and gatherings.

- Grocery store
- School
- Restaurant / café
- Town hall
- Bakery
- Gas station
- Kindergarten
- Church



Ill. 14. Temperature and precipitation analysis (DMI, 2020)

MICROCLIMATE

Temperature

The average temperatures are between 0 and 19°C with extremes of -11 to 33°C (*(1) DMI, 2020)*. The variation of the temperatures between winter and summer influence how the building must be designed to optimally take advantage of the different seasons. In cold months it would be beneficial to utilize the sun for passive heating. Outdoor spaces should be designed with the possibility of shade in summer to cool down whereas wind shading during winter is beneficial to stay warm.

Precipitation

Denmark experiences rain throughout the year with a risk of heavier rainfall during the winter months. Due to colder temperatures snowfall can occur between November and March. The reliable amount of rainwater can be a benefit for the building since it can be collected and utilized as an addition in the water handling strategy.

It is important to consider shelter in outdoor spaces while designing for the comfort of the occupants. This can be achieved by integrating covered areas of the outdoor spaces.

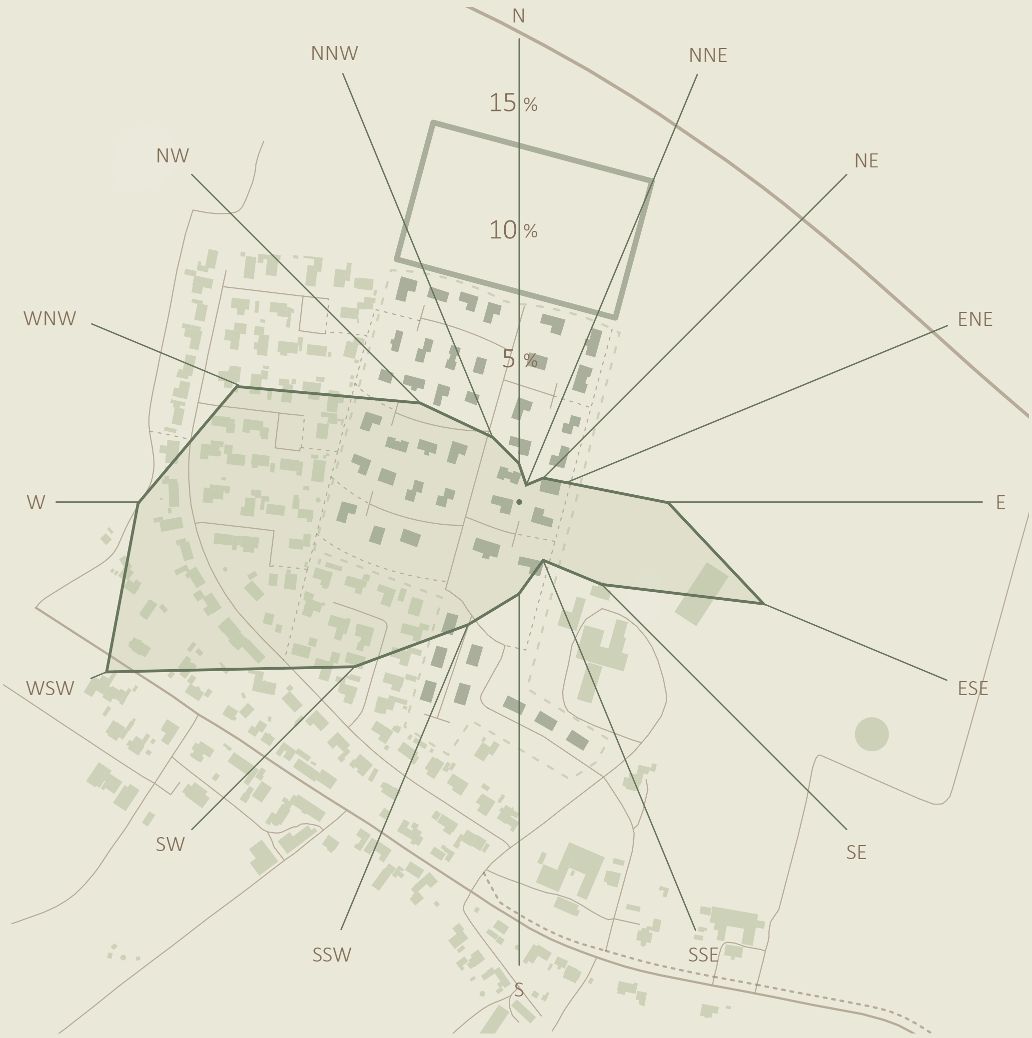
MICROCLIMATE

Wind and ventilation

30-40% of the wind is directed from the west with an average windspeed of 7,0 m/s (*(2) DMI, 2020*). Since the wind is blowing from one primary direction it is possible to adjust the design so it can benefit from the wind.

Natural ventilation strategies such as cross ventilation and thermal buoyancy depend on wind pressure. The air flows faster to create a better indoor environment when achieving negative pressure. This is possible by having bigger openable windows at the negative pressure façade (east) and smaller openable windows at the positive pressure façade (west).

Ventilation inlet should be placed in the wind direction (west) to utilize the speed of the wind. At the same time outlets must be placed opposite the wind direction (east) to make sure the used air will not pollute the fresh air.



Ill. 15. 1 : 7.500 Wind analysis (DMI, 2020)

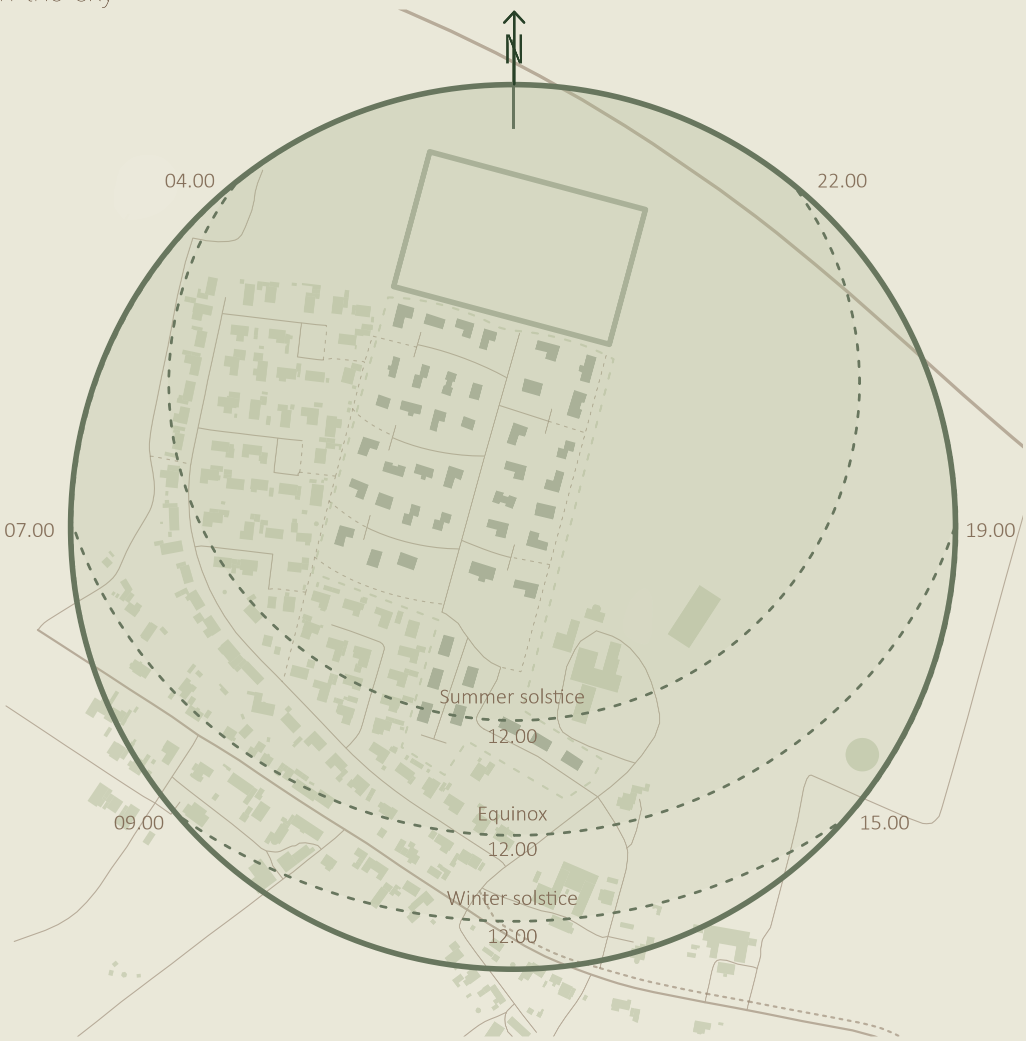
Sun and daylight

It is important to design a kindergarten with good daylight conditions to improve the development of vision for the occupants.

Daylight is categorized as diffuse light and direct light. Diffuse light is even and calm which is beneficial in a space with the necessity to concentrate. Direct light can cause glare which must be avoided.

The sun conditions are changing throughout the year with more daylight hours around summer solstice and less around winter solstice. The sun angle is also higher in the sky in summer than winter which changes the way the sun hits the building during the year. It is important to consider this while designing for passive heating and shading.

In a kindergarten with standard opening hours between 6.30-17.00 hours with no daylight will occur between equinox and winter solstice *(see ill. 16)*. This means the kindergarten must be designed with sufficient mechanical lighting for those times.



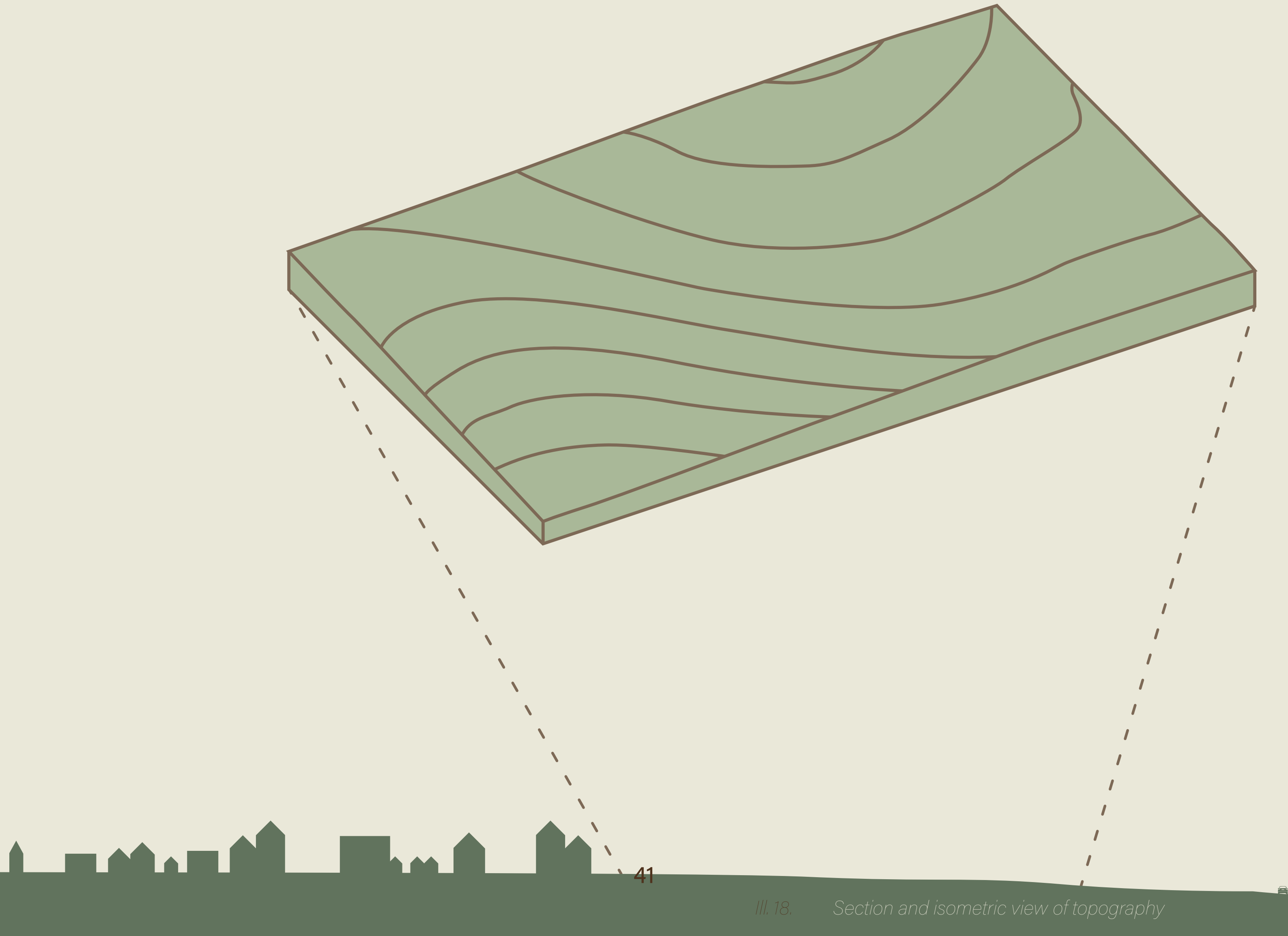
Ill. 16. 1 : 7.500 Solar analysis (DMI, 2020)

Ill. 17. 1 : 5.000 topographycal analysis

TOPOGRAPHY

There is an 8-meter topographical difference from the top corner to the bottom corner at the site. When comparing this with the knowledge about precipitation it can be concluded that a great amount of rainwater will run down the site during rainfall. Worse case scenario, the rain water will accumulate in the north-eastern corner.

It is possible to control the excess rainwater by designing a solution to guide the water through the site. The benefit of this is that water will not accumulate on site, instead the rainwater can be collected for use in the building, providing an educational experience in initiating play for those children who interact with the water source.
This will be further developed in the design process.



Ill. 18. Section and isometric view of topography

ATMOSPHERE

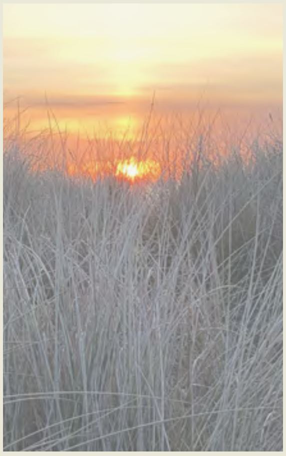
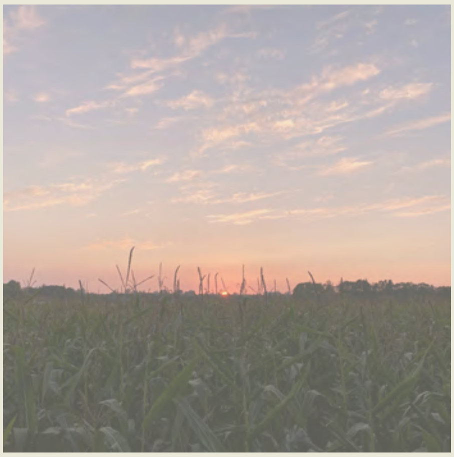
The atmosphere analysis has been conducted as a field study in the local community. Citizens of Stae, Vester Hassing and Gandrup have been given their reflections upon how they experience the atmosphere where they live, in form of a quote and photos.

The quotes have been translated from Danish to English and the photos belong to the citizens of Stae, Vester Hassing and Gandrup.

"Underestimated nature in a place where no one is lonely"

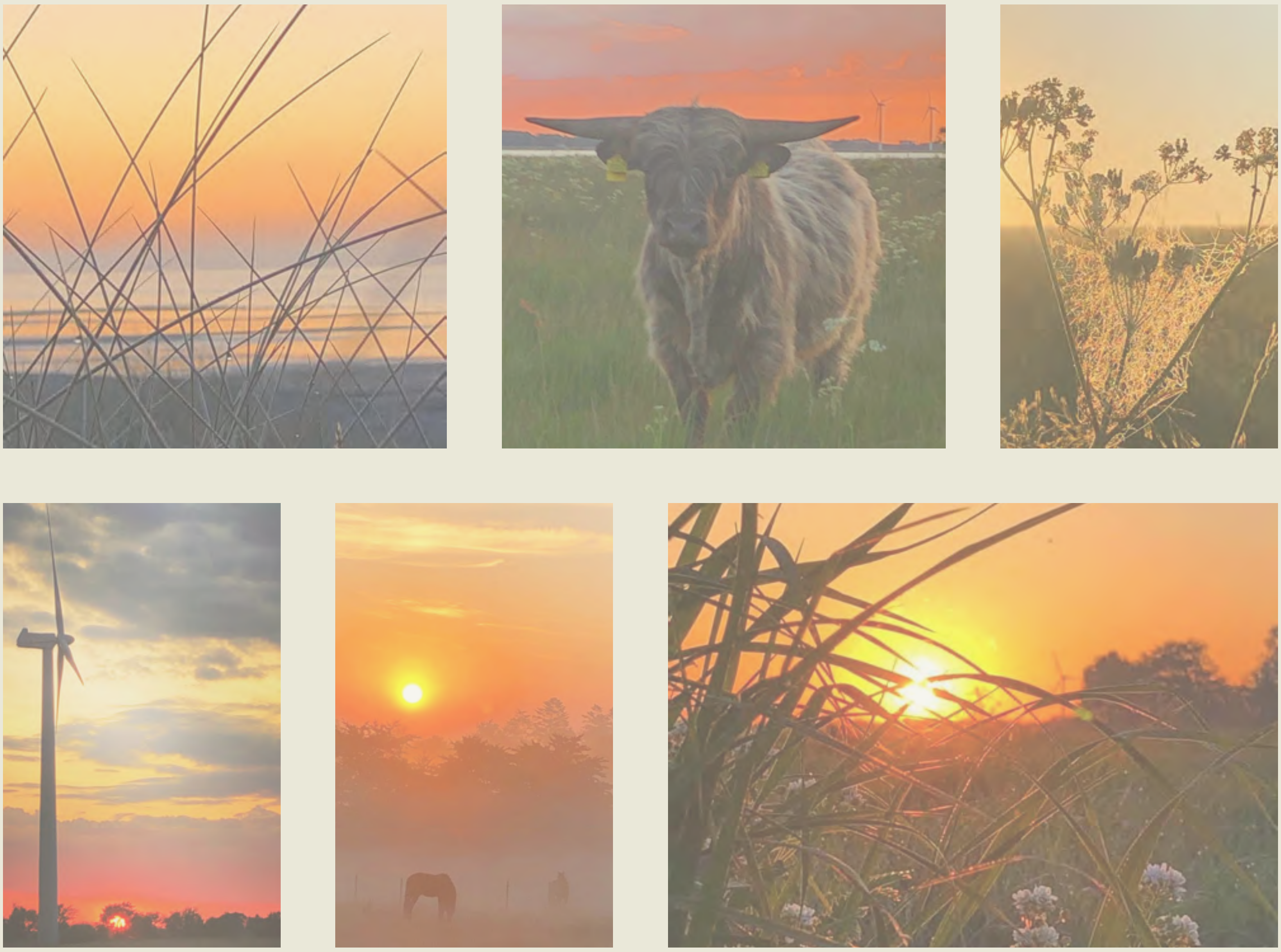
Persona: Grandmother
Connection to area: Renting a senior home



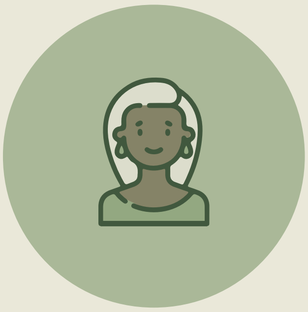

Ill. 19. Atmosphere analysis citizen A

Persona: Father
Connection to area: Owns a house



Ill. 20. Atmosphere analysis citizen B

"Where all my friends are"



Persona: Nanny - Teenage girl
Connection to area: Living with parents



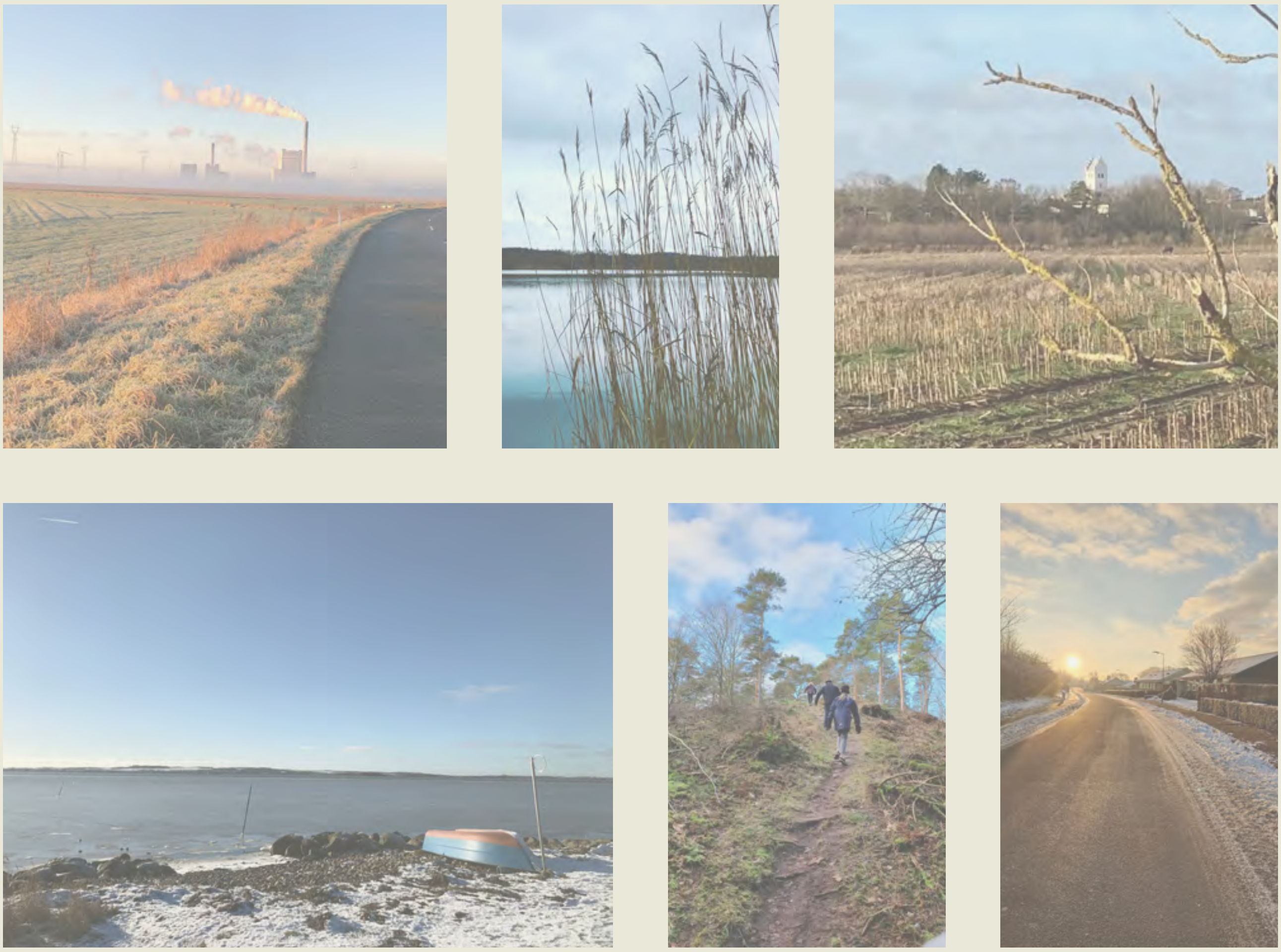



Ill. 21. *Atmosphere analysis citizen C*

"This area is my time capsule from my childhood"

Persona: Myself

Connection to area: Former citizen



Ill. 22. Atmosphere analysis citizen D

The majority of the photos focus on the nature without any buildings or people. Light and natural colors are key to achieve different moods. Not even one person left out a picture of the sunset. Seasons effect the areas in the nature which create different moods during the year

Part 03

Part 02

Part 01

ANALYSIS PHASE / USERS

Ill. 23. Mapping of users

UNFOLDING THE EVERYDAY LIFE IN A KINDERGARTEN

Mapping during free play

Movement observations of two children and one adult has been conducted from Kronens Mark nature kindergarten in Thisted, Denmark. The data has been gathered to understand the moving behavior of the target user group in a state of free play. Each analysis has been conducted in a timeframe of 10 minutes on a snowy day in February right after lunch.

The data concludes the children are active individuals who move a lot if they get the right settings. The children need spaces with different functions to unfold themselves and investigate according to their respective stimulation needs.

Behavior observations of what initiate child lead play

1. Animals
Children teasing the goat trying to make it stab objects

2. Playing with water
Filling their clothes and boots with water even though it is freezing outside

3. Carry heavy or large objects
Children on the playground helping each other carry a long stick from one end to another

4. Jumping
Daring each other to jump from one side to another at a water stream

5. Spinning
Finding joy in excessive spinning whether the child runs around the building, spinning independently on the spot or playing with the spinning wheel at the playground

6. Sandbox
Utilizing the sand to do pretended play such as "restaurant" and "construction digger"

Ill. 24. Observations of behavior

KINDERGARTEN EXPERIENCE

Ill. 25. Kindergarten experience

Ill. 26. Kindergarten experience

KINDERGARTEN EXPERIENCE

Ill. 27. Kindergarten experience

Ill. 28. Kindergarten experience

PERSONAS

The personas are based on real people. This is a tool for the design process in order to understand the users while designing and making decisions.

The four personas represent the users as an outgoing child, a shy child, a parent and a kindergarten teacher.

Name Mads-Emil
Age 5
Occupation Kindergarten

Statement
Outgoing child with a lot of energy who loves exploring and being able to try new things

Goal
Wants to be a famous football player

Need / wishes
Is easily prone to boredom and therefore, requires constant physical and mental activity

Behavior

place
indoor — outdoor

sociality
shy — social

skill development
physical — mental

level of focus
little — much

Name Albert-August
Age 3
Occupation Kindergarten

Statement
A quiet child who can focus for hours when something catches his attention

Goal
Wants to grow up to be his older brother

Need / wishes
A calm area to rest when he is over stimulated

Behavior

place
indoor — outdoor

sociality
shy — social

skill development
physical — mental

level of focus
little — much

Name Charlotte
Age 34
Occupation Parent / nurse

Statement
Prominent person in the local community. A person who stands by her beliefs and thrives in a high pace lifestyle

Goal
Teach her children values of life from an early age

Need / wishes
A creative institution that supports child development to ensure new skills for her children

Behavior

physical activity

non — alot

sociality

shy — social

mature behavior

little — much

level of focus

little — much

Name John
Age 25
Occupation Teacher assistant

Statement
Joyful person who loves outdoor activities. He enjoys telling stories and playing games with the children.

Goal
Focuses on play with an educational purpose

Need / wishes
To have fun in a creative less stressful manner

Behavior

physical activity

non — alot

sociality

shy — social

mature behavior

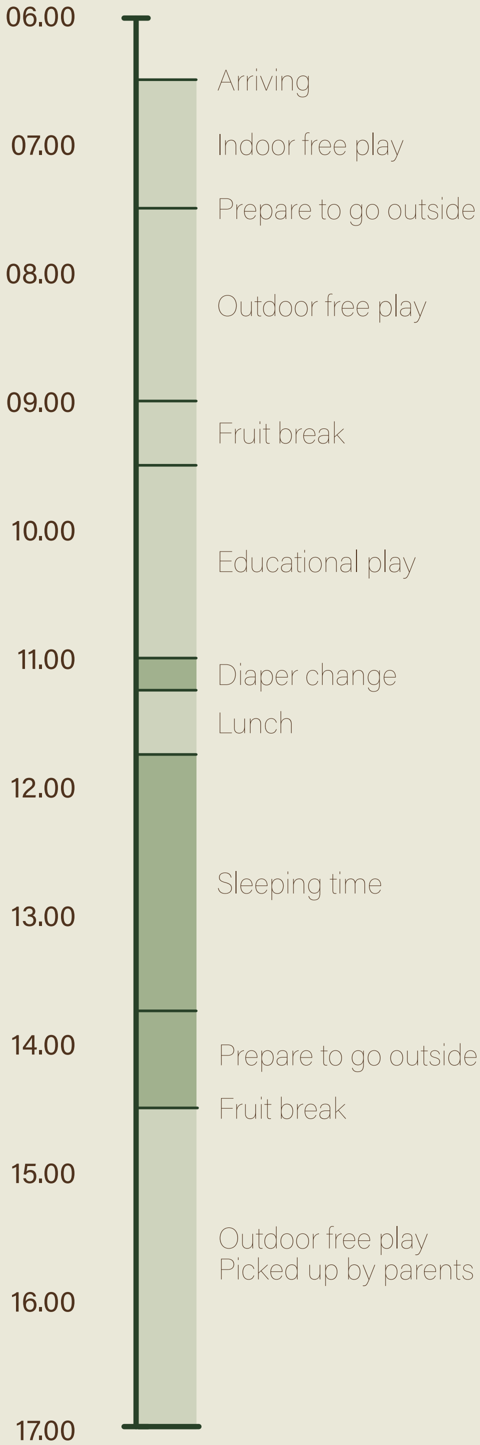
little — much

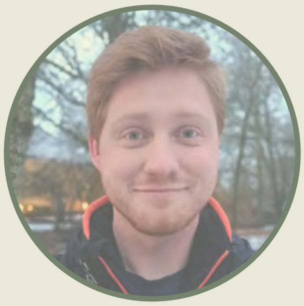
level of focus

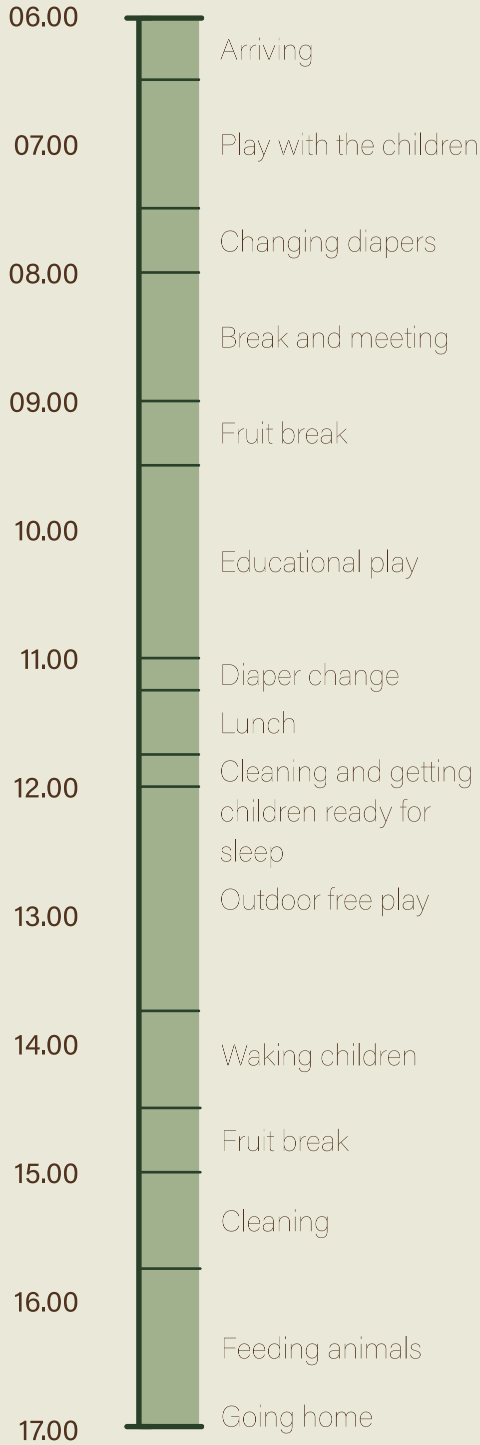
little — much

Ill. 29. Persona 1 - 4

PERSONAS - DAILY SCHEDULE







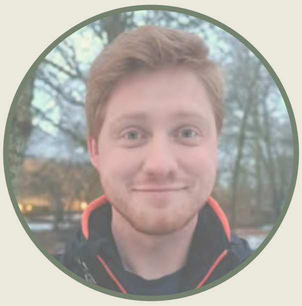
Ill. 30. Persona 1 - 4 daily time schedule - Based on observations conduted at kindergarten Kronens Mark

USERS

Primary users

Child: Mads-Emil

Child: Albert-August



Teacher: John

Secondary users

Parent: Charlotte

Local community

Part 03

Part 02

Part 01

ANALYSIS PHASE / SUSTAINABILITY

Sustainable strategies
Sustainability from the user perspective
Social sustainability – comfort requirements
Economical sustainability
Environmental sustainability

SUSTAINABLE STRATEGIES

Passive strategies

< 27
kWh / m^2 year

Active solutions

< 0
kWh / m^2 year

Zero-energy building
A zero-energy building is a building that uses less than 0 kwh/m^2 per year. The building is designed with a low energy demand. The additional energy consumption is covered by fossil free energy sources from renewable energy systems *(Anne Kirkegaard et al., 2014)*.

This building aims to fulfil the regulations for a low energy building only by passive and sustainable strategies. Furthermore, the building will aim to be zero-energy by implementing active strategies, if necessary.

DGNB
Other classification systems such as DGNB, Bream and Leed have been made which can give the building a higher classification in regards to sustainability.
DGNB is an evaluation tool which considers the entire lifecycle of the building from the sketching phase to the operation of the building. The tool is focusing on seven different categories which includes 210 sub-criteria *(DK-GBC, 2017)*.
In consideration of the whole lifecycle of the building, the kindergarten aims to achieve 11 selected DGNB sub-criteria.

Following will highlight how the goals for the kindergarten will be achieved. The information will be presented by social-, environmental- and economical sustainability to ensure a holistic approach.

Ill. 31. DGNB - showing focus areas

Social sustainability and user behavior must be included when having an ambitious target to achieve an environmentally sustainable building *(Jensen et al, 2012).* Low energy buildings usually come with facilities and technologies which must be managed *(ibid).* A lack of information or interest for the user to be educated to operate the building often leads to the building being managed another way than intended *(ibid).* The users interact with the building according to their own comfort. Understanding their behavior and teaching them what to manage regarding their needs leads to a better predicted outcome of the operation of the building which leads to a more environmentally sustainable building *(ibid).*

The users must care about sustainability of the building to gain an interest to be educated adequate to operate the building *(ibid).* This can be done with many possible outcomes. This project will focus on developing an interest for the users towards green sustainability which supports the social community in the Kindergarten and Overby Bakke.
This can be achieved by creating shared facilities for the users. These facilities will improve the social interaction between people when they are engaged in the kindergarten community. Each individual will get a feeling of ownership by the shared responsibility. This is how a process of continuous social development happens *(ibid).*

How can the build environment support this?

The design must create the opportunity for shared facilities for the occupants of the kindergarten including the local community of Overby Bakke.
The goal is to integrate solutions with educational purposes for the children which encourage interaction with the seniors. Preferably facilities which provide a sustainable quality and awareness about the building. This could be facilities such as gardening, animal care, waste- and water handling *(ibid),* which all encourage social interaction as well as supporting self-sufficient strategies with an environmentally purpose.

Furthermore, it is important to evaluate when and where to design user controlled, fixed or mechanical features according to the user behavior.
An option to ensure a controlled and educated user-controlled setup is to implement sensors which measure the indoor climate and inform the users when and what they should adjust according to their comfort while achieving the best possible building performance.

Design elements build environment

1. Sensor based design
Ensure adequate information to the users about indoor climate

2. Winding paths and hallways
Design crooked paths and hallways with invitation to make a stop which encourage random interaction between users

3. Meeting spots
Design meeting spots to encourage interaction between users

Ill. 32. Build environment design elements

1. Gardening
Implementing gardening as a tool towards a sustainable kindergarten with self-sufficient characteristics which function as an educational value for the children. Furthermore, this shared facility between the teachers, the children, and the seniors improves the social sustainability.
Crops such as vegestables can be utilized in the kitchen and flowers will contribute to the biodiversity.

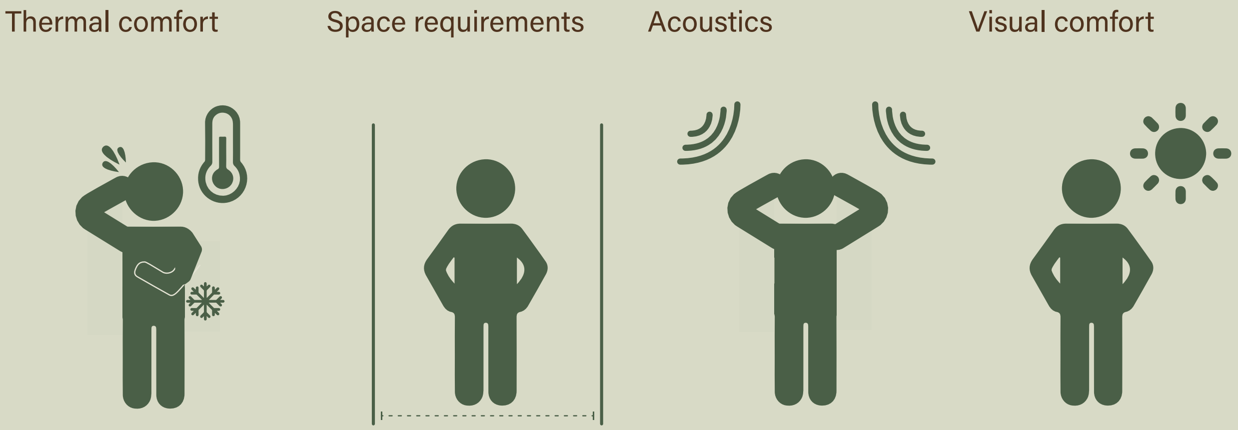
2. Animals
Implementing animals as a tool towards a sustainable kindergarten with self-sufficient characteristics which function as an educational value for the children. Furthermore, this shared facility between the teachers, the children, and the seniors improves the social sustainability.
Animal products such as eggs or milk can be utilized in the kitchen.

3. Water handling
Water collector can be managed between teachers, children and seniors. The water collector serves a primary pupose to provide the building with gray water but can also be an element which encourage play for the children.

4. Waste handling
Waste handling system has educational value for the children. The organic waste from food and animal feces can be collected and used as fertilizer for the crops.

Ill. 33. Shared facilities

Design elements social sustainability



Ill. 34. Social sustainability - comfort

Social sustainability

The aspect of social sustainability involves the users health and wellbeing including their comfort in the build environment.

Thermal comfort

· Thermal comfort will be achieved by DGNB criteria **SOC 1.1** *(DK-GBC, 2017)*:

· summer **23-26 °C**
· winter **20-24 °C**

· max. **100h** > 26 °C
· max. **25h** > 27 °C

· Temperatures will be adjusted according to passive heating and natural ventilation

· A great amount of people in a room may result in fluctuating temperatures which can be controlled by thermal mass

Space requirement

· Min 3 m2 per person *(bygningsreglementet, 2020)*
· A connection between interior and exterior

Acoustics

· Acoustic comfort will be achieved by DGNB criteria **TEC 1.2** following reverberation time *(bygningsreglementet, 2020)*:

· classrooms: **0.6s**
· common rooms for work: **0.4s**
· common rooms: **0.9s**
· hallways: **1.3s**

· Reverberation time will be adjusted by absorbent and reflective materials in the different rooms

Visual comfort

· Visual comfort is achieved by DGNB criteria **SOC 1.4** with a daylight factor at min. **2,5%** in **80%** of the workspaces *(DK-GBC, 2017)*
· Controlling direct sunlight by avoiding glare
· Aim for diffuse daylight in zones of working environment

Economical sustainability

Design elements economical sustainability

Operation and maintainance | Prefabrication | Resilience

Ill. 35. Economical sustainability design elements

Operation and maintenance

· Maintenance of the building will be considered while designing the areas and deciding the materials.

· The building will be operated all day in the weekdays which leads to many hours of full operation while the building is empty. Usage of the building outside the kindergarten's hours of use will be discussed in the design phase to ensure an effective building.

· DGNB criteria **SOC 3.3** and **ECO 2.1** will be considered in terms of flexibility and area usage

Prefabrication

· Distances and sizes in the design layout will take prefabrication into consideration to ensure similarity in the modules. Module based design is usually cheaper when similar pieces can be mass produced.

· Evaluate what to prefabricate and what to build on site according to transport, prices and standard sizes

Resilience

· Materials and construction methods will be decided on behalf of the lifespan of the building in consideration to maintenance.

Environmental sustainability

Environmental sustainability involves the responsibility towards care and wellbeing of our planet. Research shows the building industry is responsible for *40%* of the CO_2 emissions in Denmark *(Anne Kirkegaard et al., 2014)* therefore it is necessary to consider the impact which the building puts on the world's carbon footprint.
Following highlights the strategies which the kindergarten aims to achieve.

Low energy consumption
Building envelope

· The building envelope will fulfill the requirement for DGNB criteria **TEC 1.3** for following U-values extracted from **DS418** *(DK-GBC, 2017)*:

Walls: **0.20** w/(m²·k)
Foundation: **0.12** w/(m²·k)
Roof: **0.15** w/(m²·k)
Glazing: **1.2** w/(m²·k)

· Avoid thermal bridges and line losses by having a low infiltration value

Indoor air quality

· DGNB criteria **SOC 1.2** allows a max CO_2 concentration of **900 ppm** *(DK-GBC, 2017)*
· The ventilation demand will be fulfilled by utilizing **cross ventilation** or **thermal buoyancy** as a natural ventilation strategy.
· Usage of non-toxic and non-smell materials will lead to a smaller ventilation demand while calculating OLF
· By implementing heat recovery in the ventilation system the building will save energy while heating the air

Passive shading

· Passive shading will be utilized during the hot summer months. The shading will be achieved as an overhang or as greenery such as trees or plants.

Passive heating

· Passive heating will be used during cold winter months in order to lower the heating demand.
· Materials with high **thermal mass** will be beneficial to achieve a stable room temperature

Water handling

· Rainwater on site will be collected as **grey water** according to DGNB criteria **ENV 2.2**
· Overflow of rainwater on site will be utilized as a design feature to educate the children

Waste handling

· Organic waste will be collected in a septic tank which will be integrated on site

Material choices

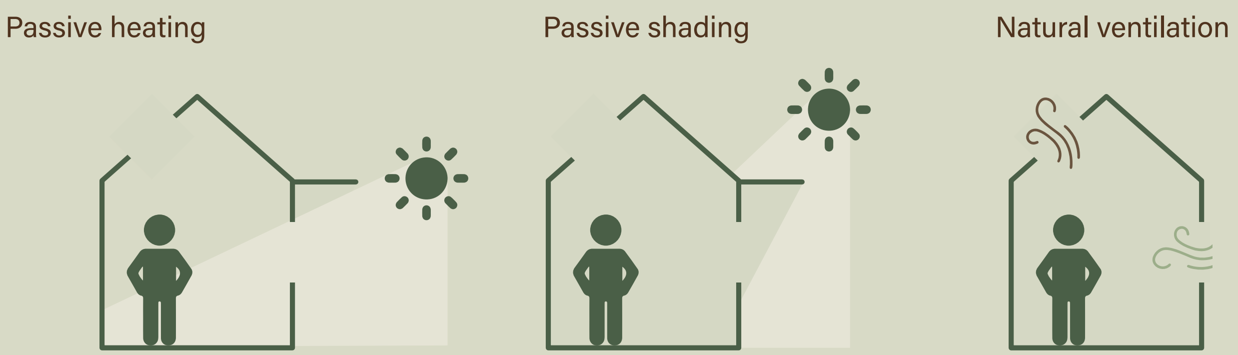
· Local materials will be selected to minimize the need for transportation
· The design will be adjusted to material standard sizes to ensure less material waste during construction.

Building envelope

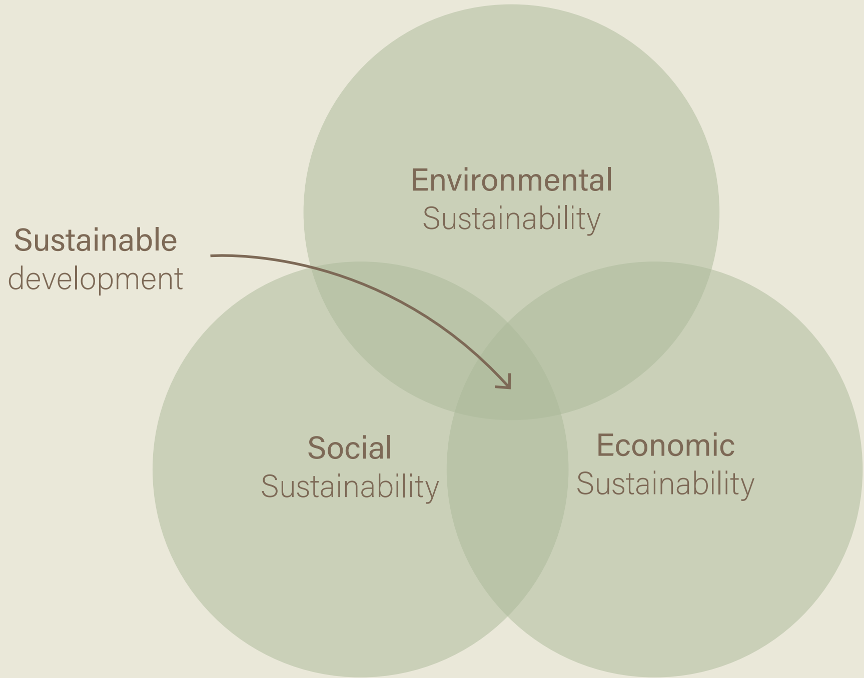
Design elements environmental sustainability

Ill. 36. Environmental sustainability design elements

Design elements passive strategies



Ill. 37. Environmental sustainability passive strategies



Ill. 38. Three types of sustainability to implement to achieve sustainable development

Part 03

Part 02

Part 01

ANALYSIS PHASE / PRE-STUDIES

Skanderborggade	/	small-sized kindergarten
Karolinelund	/	middle-sized kindergarten
Galaxen	/	big-sized kindergarten
Inspiration boards	/	reference projects

Ill. 39. Skanderborggade kindergarten

PRE-STUDY: SKANDERBORGGADE SMALL-SIZED KINDERGARTEN

Architect Dorte Mandrup

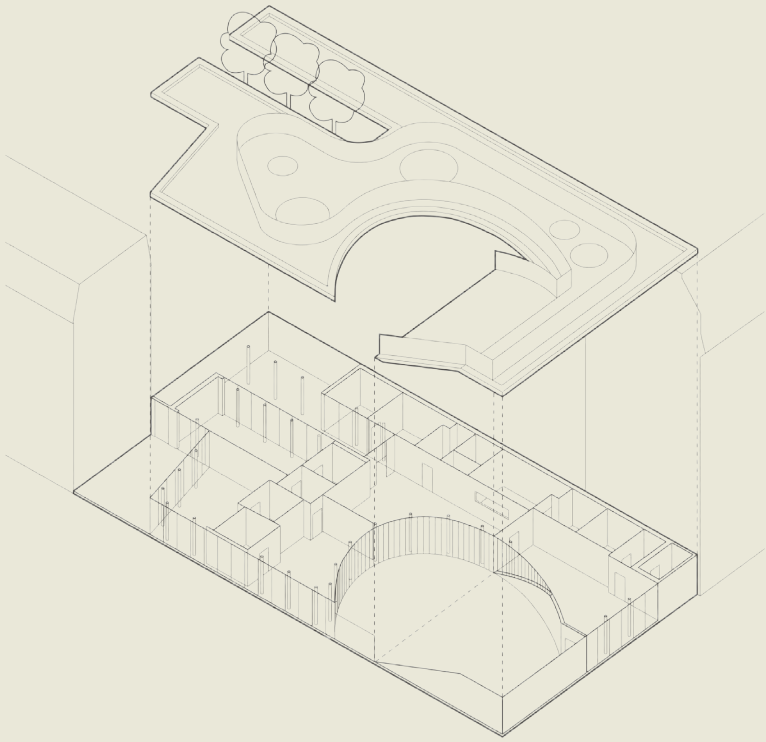
Location Copenhagen

Function Kindergarten center

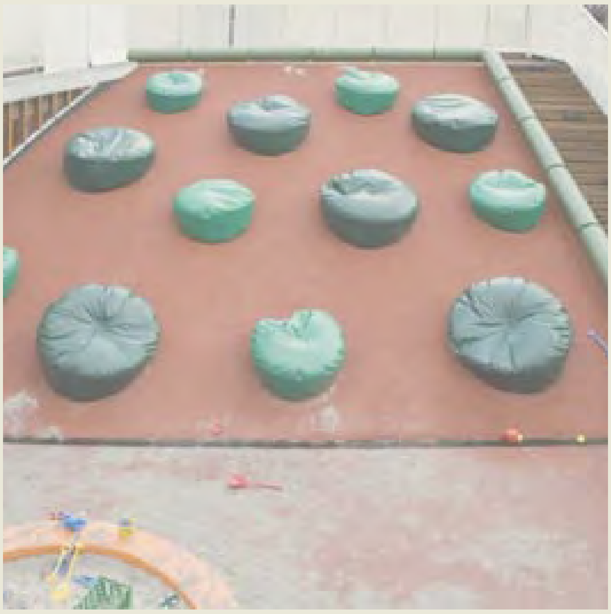
Building year 2005

Building size 530 m^2

Number of children 36



Ill. 40. Exploded diagram



Ill. 41. Sloping surface

Rolling children

The kindergarten is constructed as two plates which connects by a sloping ramp. The ramp invites two different kinds of play ideal for rolling, climbing, sliding and more. This supports physical development and improves motor skills.

Ill. 42. Roof design

Roof design

The roof is utilized as a playground for the children. This makes it possible to interact differently with the build environment and question the barrier between interior and exterior.

Room program:

Hallway:	15	m^2
Wardrobes:	45	m^2
Toilets:	30	m^2
Common rooms:	50	m^2
Group rooms:	162	m^2
Office and break room:	24	m^2
Kitchen facilities:	16	m^2
Cleaning room:	8	m^2
Technical:	8	m^2

Room program

The kindergarten is built around a round atrium providing the building with optimal daylight conditions. The building site is situated between existing building volumes which prohibit windows on the north and west façade why it is important to consider daylight.

Ill. 43. Interior Skanderborggade kindergarten

Daylight and curtain wall

Visual comfort in terms of daylight has been fulfilled by a big curtain wall from the common spaces. It has later been discovered that the curtain wall prevents thermal comfort since the building is cold during winter and too hot during summer.

Ill. 44. Karolinelund kindergarten

PRE-STUDY: KAROLINELUND MIDDLE-SIZED KINDERGARTEN

Architect BJERG Arkitekter

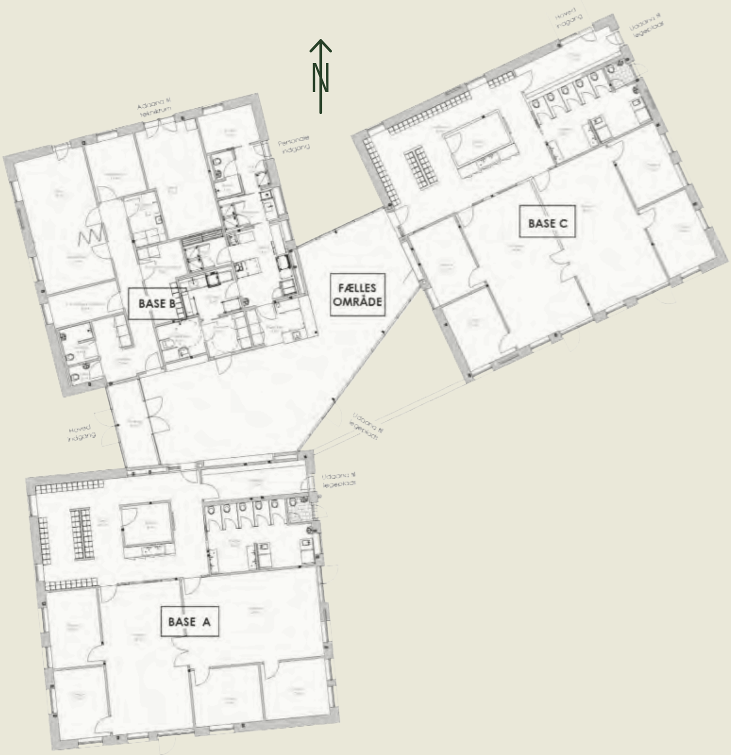
Location Aalborg C

Function Kindergarten

Building year 2017

Building size 850 m^2

Number of children 99



Ill. 45. Karolinelund plan

Ill. 46. Close up facade

Materials

Karolinelund kindergarten is the first Danish kindergarten to achieve DGNB classification platinum. This is characterized by the material choice which focuses on the entire lifecycle and by the wellbeing of the users.

Ill. 47. Wall section

Sustainable awareness

The architects aimed to achieve sustainable awareness for the children from an early age. This is achieved by implementing visible and accessible features to educate the children such as a wall section, technical facilities, water system and solar cells.

Room program:

Hallway:	59	m²
Wardrobes:	106	m²
Storage:	12	m²
Toilets:	67	m²
Common rooms:	250	m²
Group rooms:	260	m²
Office and break room:	56	m²
Kitchen facilities:	42	m²
Cleaning room:	5	m²
Technical:	21	m²

Room program

The building is separated in three parts. Two for children groups and one for teachers and technical facilities. The different bases are connected by a common room which allows a great amount of daylight in the building and acts as a tool to create a transition between exterior and interior.

Ill. 48. Landscape

Landscape

The landscape is designed with a sustainable mindset which also supports the user goals and needs. The hills are created by existing earth from construction and affords the children to different kinds of play which involve speed, sliding, spinning, rolling, tumble play, hiding and getting lost. The green roof has a sustainable function for the building and allows the building blend in with the landscape.

Ill. 49. Galaxen kindergarten

PRE-STUDY: GALAXEN
BIG-SIZED KINDERGARTEN

Architect Kullegaard

Location Jyderup

Function Kindergarten center

Building year 2016

Building size 1.300 m²

Number of children 180

Ill. 50. Galaxen kindergarten plan

Ill. 51. *Affordance to play*

Ill. 52. *Shared activities*

Affordance to play

The interior of the building invites children to different types of play involving climbing, hiding, pretend play and playing with objects. The building typology results in a varying room height which supports different children's needs e.g. high pace activity or concentration.

Shared kitchen

The building plan structured with shared facilities for the users. Facilities such as shared kitchen, courtyard, and workshops which support the community across different kindergarten groups.

Room program:

Hallway:	79	m^2
Wardrobes:	161	m^2
Storage:	23	m^2
Toilets:	127	m^2
Common rooms:	288	m^2
Group rooms:	460	m^2
Office and break room:	78	m^2
Kitchen facilities:	32	m^2
Cleaning room:	7	m^2

Ill. 53. *Landscape*

Room program

The building plan is structured in several smaller group areas circulating two main common rooms providing the building with additional daylight forming a shared courtyard. Each group with their own workshop area, wardrobe, and toilet.

Landscape

The exterior takes advantage of the existing landscape to initiate different kinds of play, including sliding, jumping and more. The children have endless types of activities to do which keeps them active and curious. The kindergarten has a great focus on the children spending time outdoor – why the building is designed with toilets, storage and more with direct access from outside.

INSPIRATION BOARD
REFERENCE PROJECTS


Flat, smooth, climbable surface


Integrated playground


Combined kitchen and greenhouse


Climbable, interactive, risky play

Interacting with the building, risky play

Ill. 54. Reference photos gathered from Pinterest board

INSPIRATION BOARD
REFERENCE PROJECTS


Outdoor - indoor connection


Outdoor - indoor connection. Greenhouse


Playful water drainage system


Encourage exercise


Interactional play with objects

Ill. 55. Reference photos gathered from Pinterest board

INSPIRATION BOARD
FIELD STUDIES

Atmosphere, mood and materiality

Playground hiding in topography

Integrated playground with topography

Integration of animals

Nature and fields

Different ground mterials

Ill. 56. Reference photos gathered from field studies

Part 03

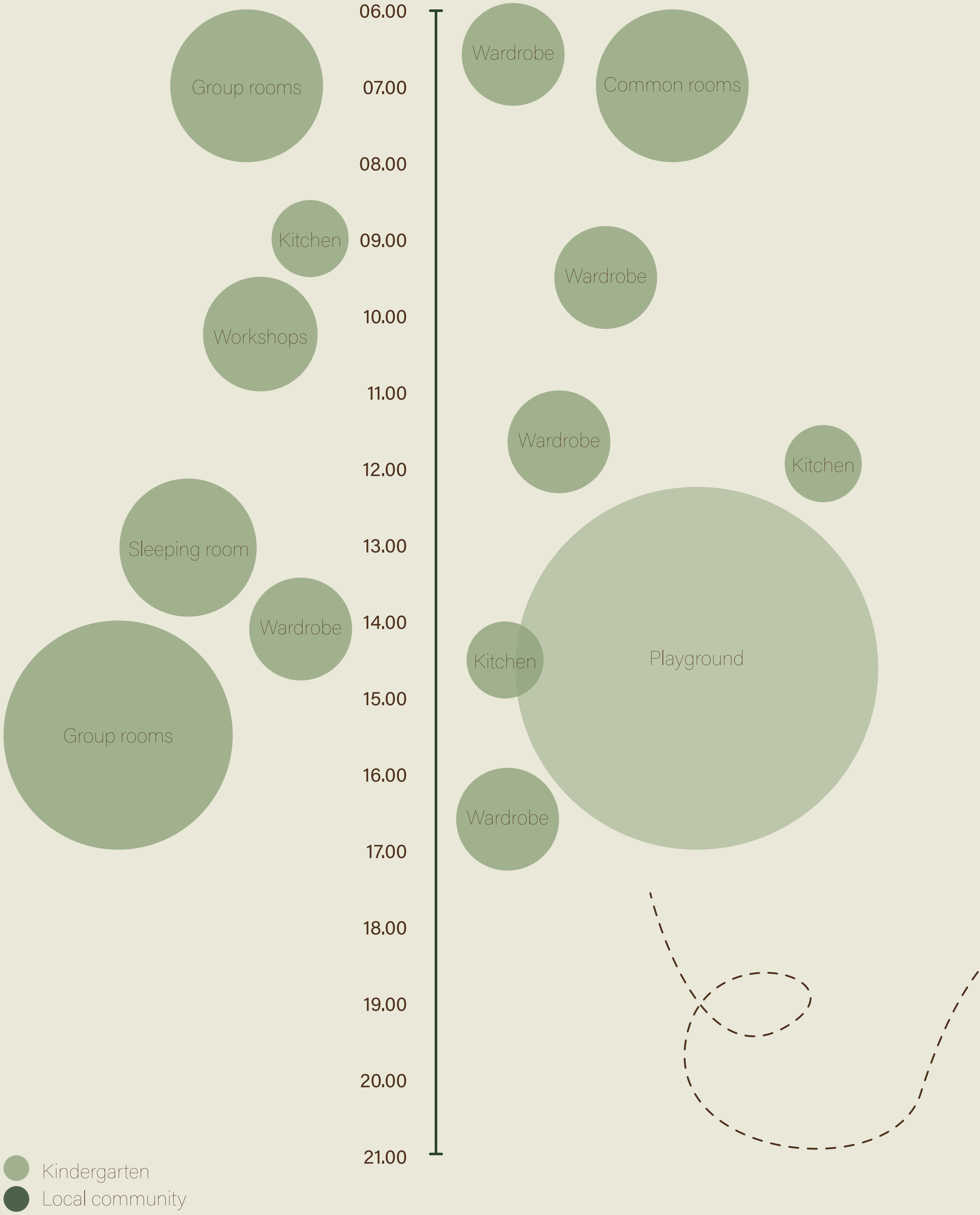
Part 02

Part 01

PROGRAM

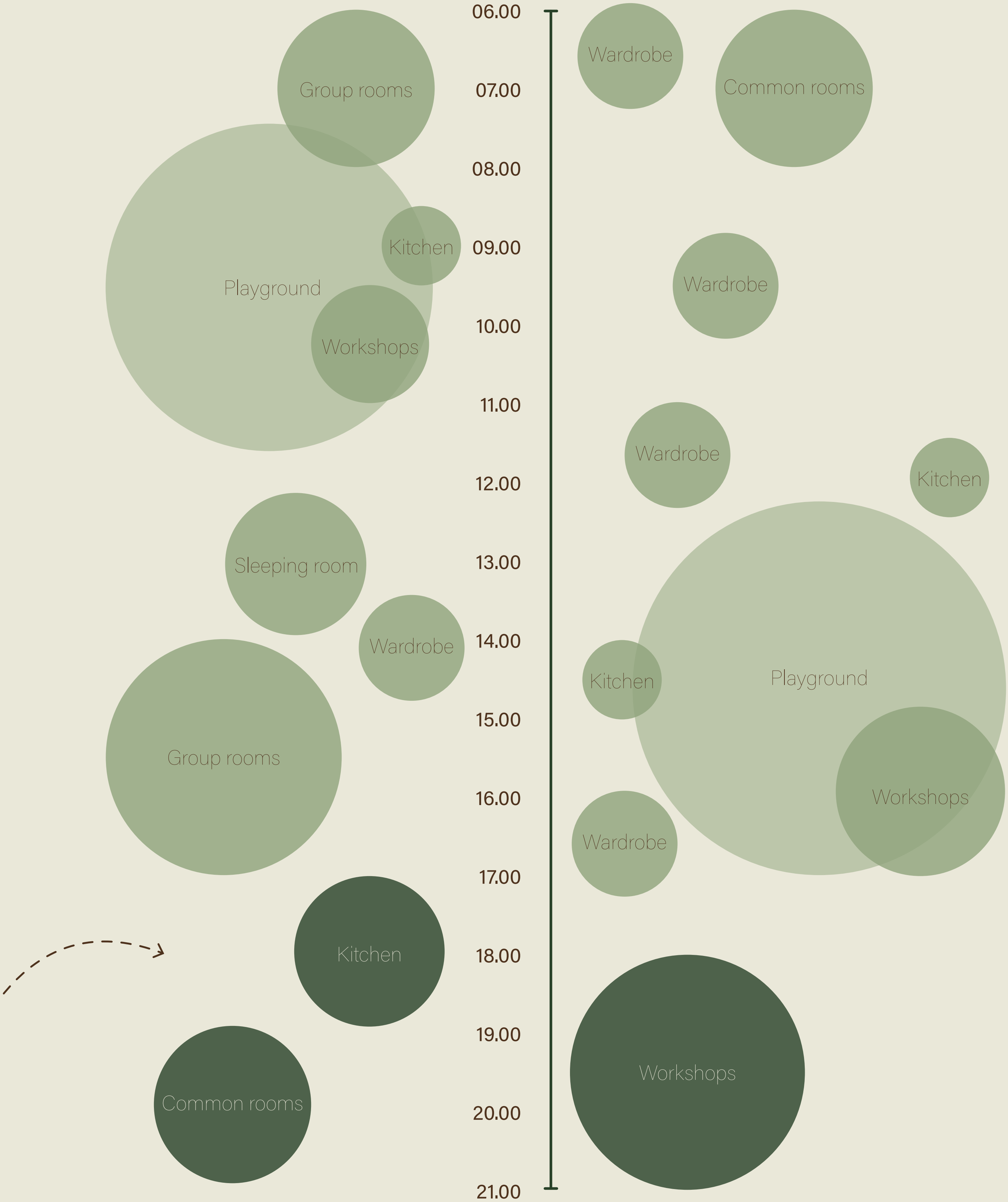
Sustainable strategies
Sustainability from the user perspective
Social sustainability – comfort requirements
Economical sustainability
Environmental sustainability

CURRENT ROOM SCHEDULE



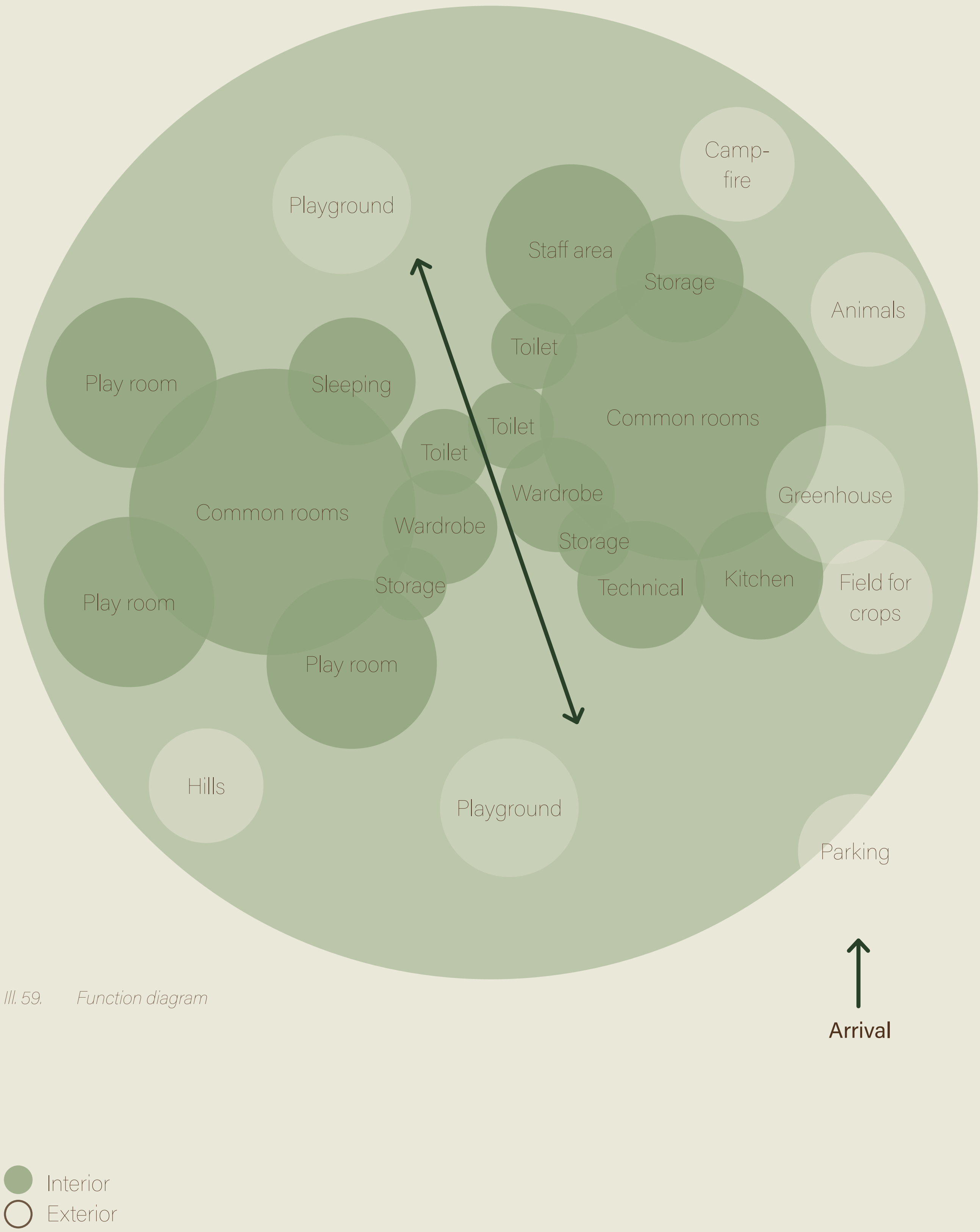
Ill. 57. Room function diagram - Schedule, Based on persona schedule

TARGET ROOM SCHEDULE



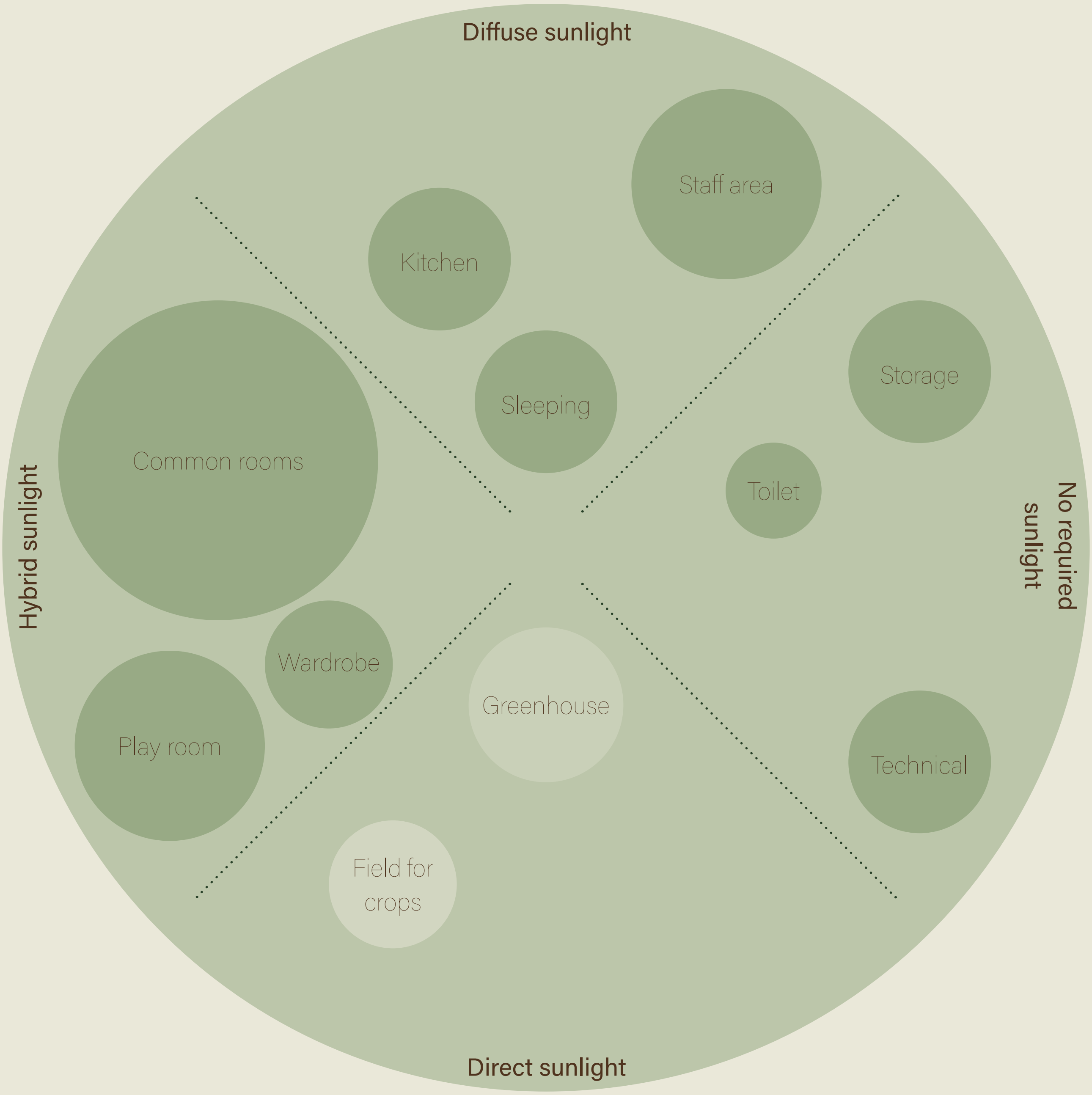
Ill. 58. Room function diagram - Overby Bakke

FUNCTION DIAGRAM



Ill. 59. Function diagram

DAYLIGHT DIAGRAM



Ill. 60. Daylight diagram

ROOM PROGRAM

Room	Size
Common rooms	200 m^2
Play rooms	100 m^2
Workshops	70 m^2
Sleeping	30 m^2
Staff area	75 m^2
Wardrobes	60 m^2
Kitchen facilities	30 m^2
Toilets	50 m^2
Hallways	max 7% of total m^2
Storage	20 m^2
Technical	21 m^2
Cleaning room	6 m^2
	600 m^2

Atmosphere and function	Other aspects
Playful	Act as the heart of the building
Playful Focused / educational Comfortable	 Ventilate according to function Possibility to block daylight
Comfortable / focused	Is not allowed for children
Practical	Each child must have a personal wardrobe space
Practival / focused	Designed in child scale
Practical	Space for diaper change
Playful	- -
Practical	Ability to store extra furniture for rental hours
Practical	Proper access for maintainance
Practical	- -

VENTILATION PROGRAM

Room	Volume [V]	Number of people [people]	Activity level [MET]	People load [q] *0,017 · MET · people*
Playroom type 1 x2	23 m^2	3	1.2	0.06
Playroom type 2 x2	14 m^2	3	1.2	0.06
Sleeping room	33 m^2	5	1.2	0.10
Common room type 1	157 m^2	50	1.2	1.,02
Common room type 2	66 m^2	10	1.2	0.20
Wardrobe x2	28 m^2	5	1.2	0.10
Toilet x2	19 m^2	3	1.2	0.06
Hallway	44 m^2	3	1.2	0.06
Kitchen	28 m^2	3	1.2	0.06
Staff toilet	16 m^2	3	1.2	0.06
Break room	51 m^2	5	1.2	0.10
Office x2	10 m^2	3	1.2	0.06

Category B

Outdoor CO_2 concentration (C_u) = 650 ppm
Background pollution (C_0) = 350 ppm

Target air quality (C_c) = 1,4 dp
Outdoor air quality = 0 dp

Building load (low emission) = 0.1 olf / m^2

Air change CO_2 [h^{-1}] *q / (V (C_u - C_0))*	Sensory load [olf] *olf* · people + building load · area	Air change sensory [h^{-1}] *Volume flow / V*	Sensory volume flow [m^3 / h] *air change* · V
1.46 l/s	5.3	2.11 l/s	136 m^3/h
2.4 l/s	4.4	2.4 l/s	113 m^3/h
1.70 l/s	8.3	2.89 l/s	213 m^3/h
3.57 l/s	65.7	3.84 l/s	1690 m^3/h
1.70 l/s	16.6	2.31 l/s	427 m^3/h
2.00 l/s	7.8	2.56 l/s	200 m^3/h
1.77 l/s	4.9	2.37 l/s	126 m^3/h
0.76 l/s	7.4	1.54 l/s	190 m^3/h
1.2 l/s	5.8	1.9 l/s	150 m^3/h
2.1 l/s	4.6	2.64 l/s	118 m^3/h
0.86 l/s	11.5	1.62 l/s	295 m^3/h
3.36 l/s	4.0	3.67 l/s	103 m^3/h
			4.226 m^3/h

↑

This value will be used to determine the ventilation unit and strategy

DESIGN CRITERIA

Users

Design to initiate learning through play according to the theoretical aspects and practical observations

Design for social wellbeing by implementing shared facilities which encourage interaction such as kitchen, animals, gardening etc.

Design for optimal visual-, thermal-, acoustic-, and atmospheric comfort for the occupants

Implement user-controlled features with sensors

Sustainability

Reach zero energy building by implementing passive and active strategies taking advantage of the microclimate

Implement rainwater collection

Implement self-sufficient strategies such as farming facilities

Make sustainable functions visible or interactive to achieve sustainable awareness

Building and site

Exploit the atmosphere and surrounding nature for farming

Design with the purpose of full-time occupation of the building including both children, teachers, parents and local community

Implement a water drainage system in case of heavy rains which initiate play

Blur the boundary between interior and exterior both visually and functionally

VISION

The vision of Overby Bakke kindergarten is a building which sustain the everyday life of the occupants. The children in the build environment are promoting their individual development through play. Furthermore, the building implements a range of affordances, inviting the children to challenge themselves on an everyday basis. The building must be design with objective elements, avoiding the build environment to dictate which types of play certain areas sustain. This invites the child's own perception to develop different types of play.
Designing a building which support child lead free play, results in a relaxed work environment for the teachers, making sure they spend their time efficiently on educational- or game play etc.

The atmosphere in the area will be reflected in the type of kindergarten being built. Ensuring focus on nature and farming facilities as well as designing to achieve a healthy indoor environment creating awareness on sustainability.

Inviting the local community of Overby Bakke into the everyday life of the kindergarten encourage the children to attend activities across generations stimulating their curiosity and creativity. The senior community will be invited to help taking care of shared farming facilities during occupied hours whereas parents will operate the facilities in the weekend. Shared spaces will be open for rent to the community ensuring the building to be more efficiently operated.

LITERATURE

Books, articles, journals, ect.

Andrea Jelic, Michael Martin, Lea Holst Laursen, Tenna Doktor Olsen Tvedebrink, , Lars Brorson Fich, & Lydia Immanuela Oehlwien, (2020). *Children, play, and the build environment: What can we learn from co-creation and embodied cognitive science?*. CoC Playful Minds.

Anne Kirkegaard, B., Knudstrup, M., Jensen, R. and Katic, I. (2014). *Zero Energy Buildings – Design Principles and Built Examples*. Aalborg: Aalborg University.

Christine Antorini, CA., Gitte Andersen, GA. (2017). *Kloge kvadratmeter: Skjulte ressourcer til bedre læringsmiljø* (1.edition) PRAXIS.
https://issuu.com/praxisflips/docs/164007-1-kloge-kvadratmeter-uddrag

Dansk Standard: *DS/CEN/CR 1752 Ventilation i bygninger - projekteringskriterier for indeklimaet*. page 12-16, 107. 1. edition. Dansk Standard,
2001.

Green Building Council Denmark (2017) *DGNB system Denmark* (1. edition) Copenhagen

Jesper Ole Jensen, Michael Søgaard Jørgensen, Morten Elle & Erik Hagelskjær Lauridsen (2012) *Has social sustainability left the building? The recent conceptualization of "sustainability" in Danish buildings, Sustainability: Science, Practice and Policy*, 8:1, 94-105, DOI: 10.1080/15487733.2012.11908088

Knudstrup, MA (2005), *Architecture as integrated design*. in L Botin & O Pihl (ed.), Pandora's Box: Method Anthology. Aalborg University Publishers, Aalborg, page 13-29

Internet sources

Aalborg Kommune. (2016). *BEDRE Overblik: Temperaturmåling på erhvervsudviklingen*
i Aalborg - Tema: Erhverv of beskæftigelse . BEDRE Overblik. Last accessed: 02.11.2020
https://www.aalborg.dk/media/4764753/bedreoverblik-analyse-om-erhverv-og-beskaeftigelse-juni-2016.pdf

Aalborg Kommune. (2009) *Befolkning, Byer.* Last accessed: 09.02.2021
https://apps.aalborgkommune.dk/statistik/webaarbog/aarbog09/struktur/Befolkning.html#Omr%C3%A5derByer

Aalborg Kommune. (2017). *Kommuneplan: Tillæg 9.016 for boliger ved Overby Bakke i*
Stae . Aalborg. Last accessed: 02.11.2020
https://www.aalborg.dk/usercontrols/AalborgKommune/Referater/Pdf.aspx?pdfnavn=18592298-17531431-1.pdf&type=bilag&pdfid=87560

Aalborg Kommune. (2018, 23.03). *Lokalplan 9-6-108: Boliger, Overby Bakke, Stae, Landområde Hals* . Lokalplan. Last accessed: 03.11.2020
https://dokument.plandata.dk/20-3964648-1521743113820.pdf

Aalborg Kommune & COWI. (2020, Juni). *Aalborg Befolkningsprognose Aalborg*. Last accessed: 03.11.2020
https://www.aalborg.dk/media/12451989/se-analyse-befolkningsprognose.pdf

Bygningsreglementet (2018) *Bygningens indretning 229*. Last accessed: 20.05.2021
https://bygningsreglementet.dk/Tekniske-bestemmelser/09/Krav/199-213

Bygningsreglementet (2018) *Lydforhold (368 - 376). Last accessed 20.05.2021*
https://bygningsreglementet.dk/Historisk/BR18-Version1/Tekniske-bestemmelser/17/Vejledninger/Generel-vejledning

(1) DMI. (2020) *Vejrarkiv*. Last accessed: 12.02.2021
https://www.dmi.dk/vejrarkiv/

(2) DMI. (2020) *Vind I Danmark*. Last accessed: 11.02.2021
https://www.dmi.dk/klima/temaforside-klimaet-frem-til-i-dag/vind-i-danmark/

Kristen Hicks. (2015) *5 Benefits of Putting a Preeschool in a Nursing Home, Senior Advisor*. Last accessed: 10.02.2021
https://www.senioradvisor.com/blog/2017/02/5-benefits-of-putting-a-preschool-in-a-nursing-home/

ILLUSTRATIONS

Illustrations which are not mentioned in this list are owned or created by Ida-Katrine Arend Grün Hansen

Ill. 39 – Skanderborggade kindergarten
Designed by: Dorte Mandrup
Photo by: Dorte Mandrup Architects
Location: https://www.dortemandrup.dk/work/skanderborggade-day-care-centre-denmark
Last accessed: 19.02.2021

Ill. 40 – Exploded diagram
Designed by: Dorte Mandrup
Photo by: Dorte Mandrup Architects
Location: https://www.dortemandrup.dk/work/skanderborggade-day-care-centre-denmark
Last accessed: 19.02.2021

Ill. 41 – Sloping surface
Designed by: Dorte Mandrup
Photo by: Dorte Mandrup Architects
Location: https://www.dortemandrup.dk/work/skanderborggade-day-care-centre-denmark
Last accessed: 19.02.2021

Ill. 42 – Roof design
Designed by: Dorte Mandrup
Photo by: Dorte Mandrup Architects
Location: https://www.dortemandrup.dk/work/skanderborggade-day-care-centre-denmark
Last accessed: 19.02.2021

Ill. 43 – Interior Skanderborggade kindergarten
Designed by: Dorte Mandrup
Photo by: Dorte Mandrup Architects
Location: https://www.dortemandrup.dk/work/skanderborggade-day-care-centre-denmark
Last accessed: 19.02.2021

Ill. 44 – Karolinelund kindergarten
Designed by: BJERG Arkitekter
Photo by: BJERG Arkitekter
Location: http://www.bjerg.nu/projects/boernehaven-karolinelunden/
Last accessed: 19.02.2021

Ill. 45 – Karolinelund plan
Designed by: BJERG Arkitekter
Photo by: BJERG Arkitekter
Location: http://www.bjerg.nu/projects/boernehaven-karolinelunden/
Last accessed: 19.02.2021

Ill. 46 – Close up facade
Designed by: BJERG Arkitekter
Photo by: BJERG Arkitekter
Location: http://www.bjerg.nu/projects/boernehaven-karolinelunden/
Last accessed: 19.02.2021

Ill. 47 – Wall section
Designed by: BJERG Arkitekter
Photo by: BJERG Arkitekter
Location: http://www.bjerg.nu/projects/boernehaven-karolinelunden/
Last accessed: 19.02.2021

Ill. 48 – Landscape
Designed by: BJERG Arkitekter
Photo by: BJERG Arkitekter
Location: http://www.bjerg.nu/projects/boernehaven-karolinelunden/
Last accessed: 19.02.2021

Ill. 49 – Galaxen kindergarten
Designed by: Kullegaard
Photo by: Ricky John Molloy
Location: https://kullegaard.dk/projekter/nyt-boernehus-i-jyderup/
Last accessed: 19.02.2021

Ill. 50 – Galaxen kindergarten plan
Designed by: Kullegaard
Photo by: Kullegaard
Location: https://www.archdaily.com/900122/galaxen-day-care-center-kullegaard/5b71a10af197cc66a90000b5-galaxen-day-care-center-kullegaard-photo?nextproject=no
Last accessed: 19.02.2021

Ill. 51 – Affordance to play
Designed by: Kullegaard
Photo by: Ricky John Molloy
Location: https://kullegaard.dk/projekter/nyt-boernehus-i-jyderup/
Last accessed: 19.02.2021

Ill. 52 – Shared activities
Designed by: Kullegaard
Photo by: Ricky John Molloy
Location: https://kullegaard.dk/projekter/nyt-boernehus-i-jyderup/
Last accessed: 19.02.2021

Ill. 53 – Landscape
Designed by: Kullegaard
Photo by: Ricky John Molloy
Location: https://kullegaard.dk/projekter/nyt-boernehus-i-jyderup/
Last accessed: 19.02.2021

Ill. 54 - Reference photos gathered from Pinterest boards
Location: https://pin.it/27LwQAs
Last accessed: 18.05.2021

Ill. 55 - Reference photos gathered from Pinterest boards
Location: https://pin.it/27LwQAs
Last accessed: 18.05.2021

PART 02

Master Thesis 2021

Aalborg University

Overby Bakke Kindergarten

57°05'10.3"N 10°05'09.7"E

Ida-Katrine Arend Grün Hansen

TITLE

Aalborg University
Master in Architecture

Department
Architecture, Design and Media Technology

Semester MSc04
Master Thesis - Overby Bakke Kindergarten
01.02.2021 - 15.06.2021

Group 16

Submission 27.05.2021

Supervisor
Tenna Doktor Olsen Tvedebrink

Part
2/3 - Sketching- and synthesis phase

Pages
66

Ida-Katrine Arend Grün Hansen

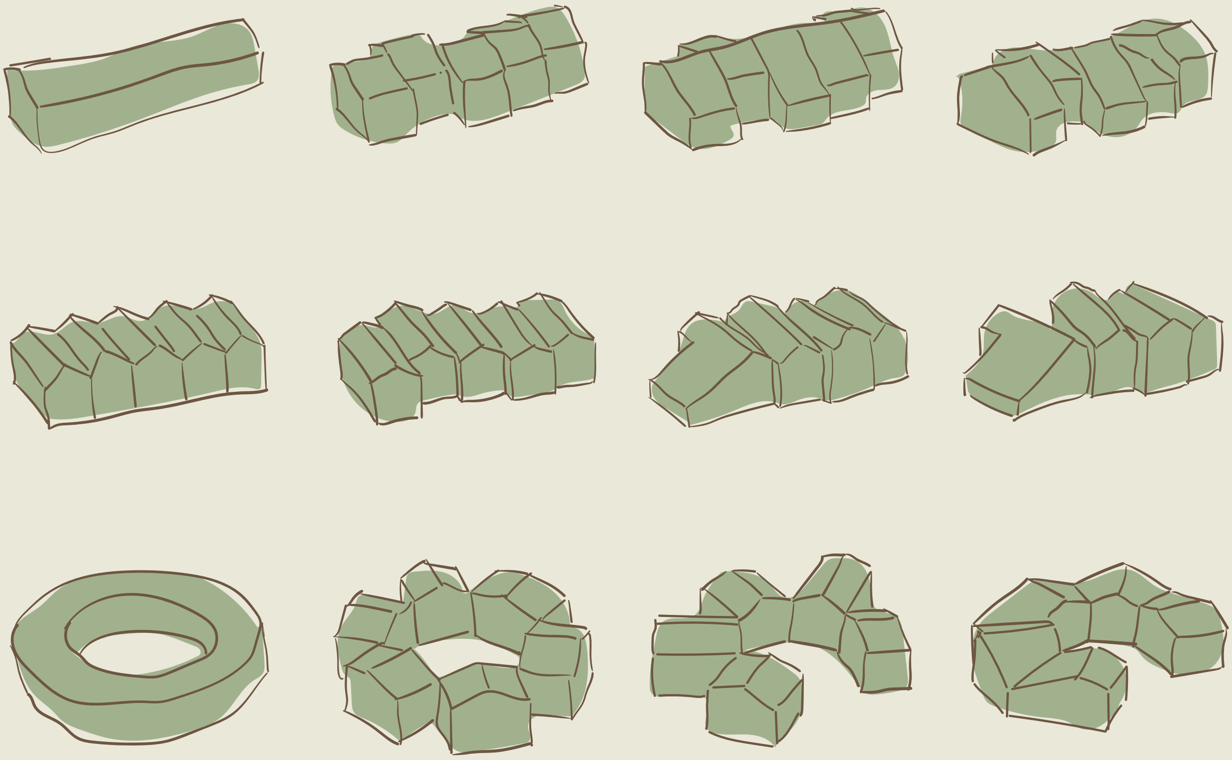
READER'S GUIDE

This report is structured by the integrated design process, divided into three parts: **01** Problem- and analysis, **02** sketching- and synthesis, and **03** presentation. This is part **02** representing the sketching- and synthesis phase of the project.

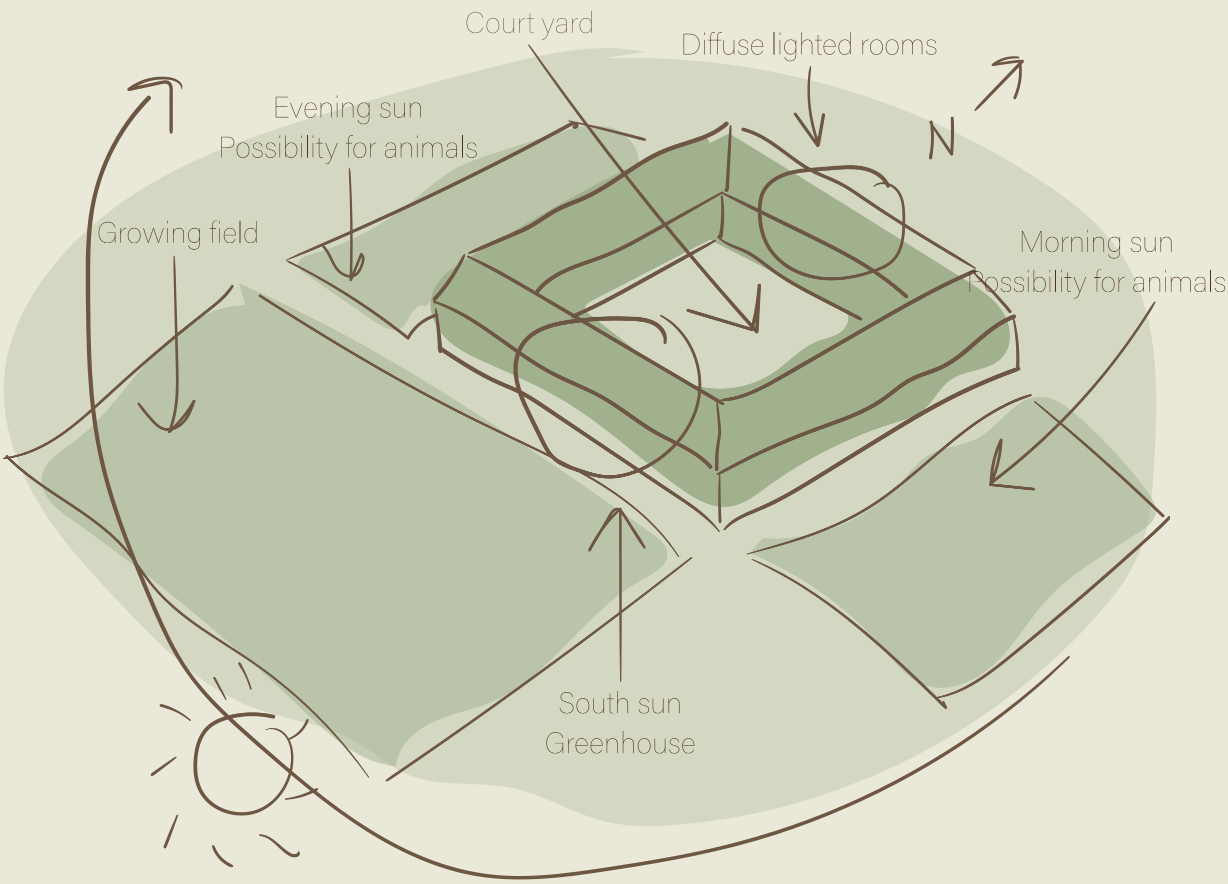
These phases document the development and process of designing the building. Both phases will be registered together since each design element has been developed through both phases.

CONTENT

INITIAL SKETCHING



Ill. 1. Initial volume sketches

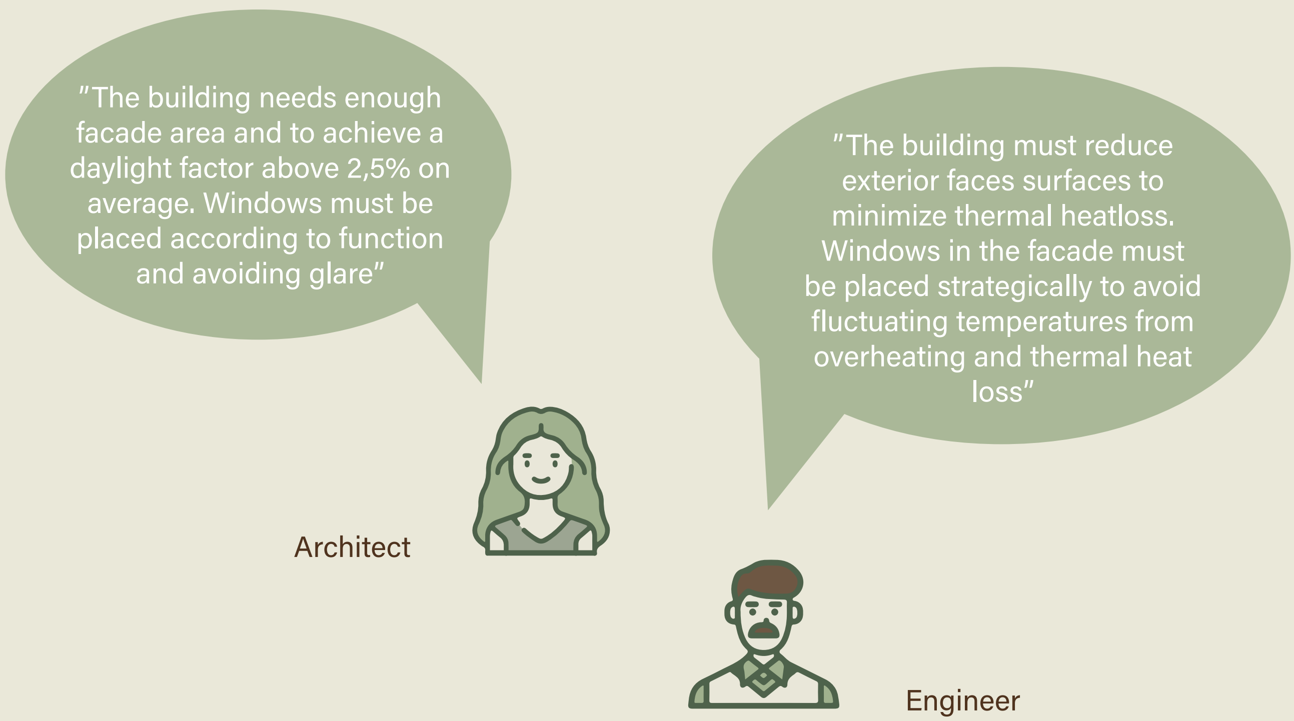


Ill. 2. Initial function sketch

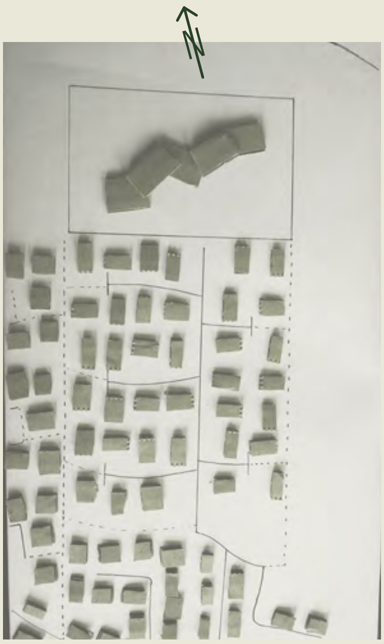
Initial sketching visualized ideas and possibilities for the design. with no consideration of goals or concept. Considerations from both architecture and engineering have been adressed in this process. This sketching process considered shape, facade area and microclimate as a kickstarter to understand which opportunities the site and goals for design have in common.

Each sketch has individual potential. Contradictions and similarities between them has not been considered in this stage of the sketching phase.

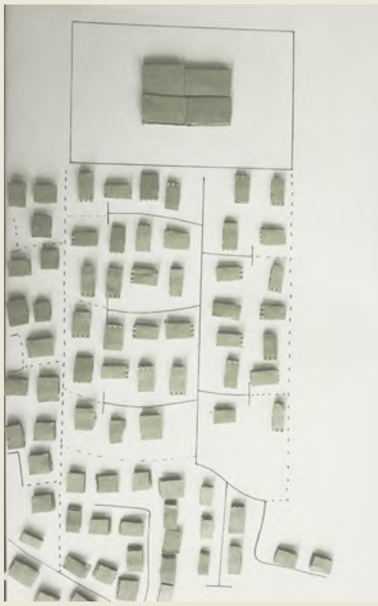
Following page shows a volume study of which the initial sketching has been based on



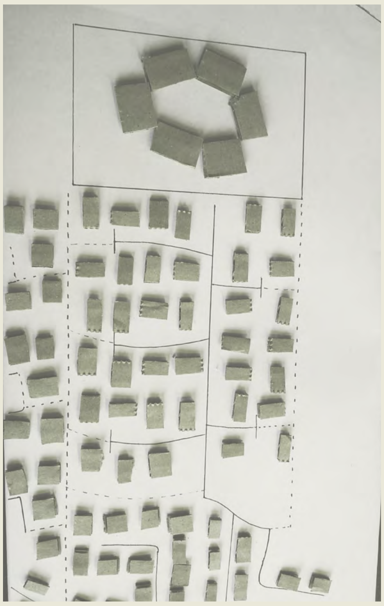
Ill. 3. Blocking the west wind



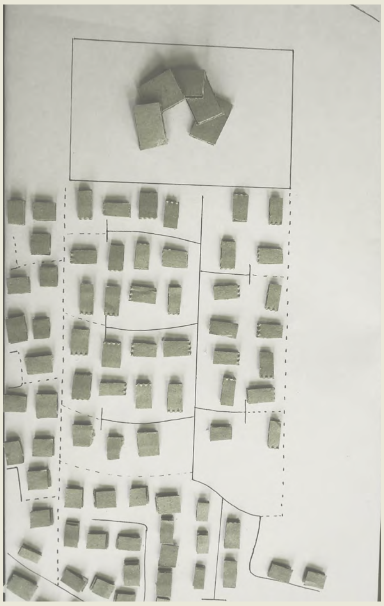
Ill. 4. Shape for less wind presure



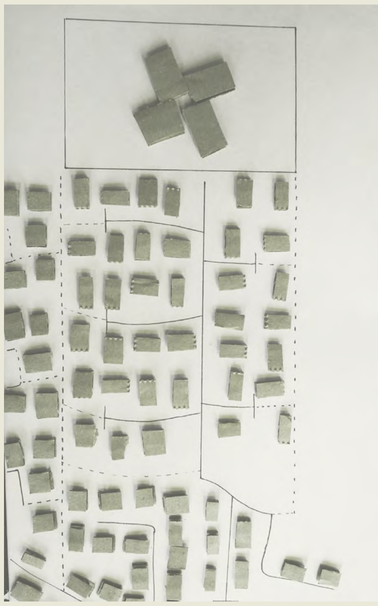
Ill. 5. Volume less thermal bridges



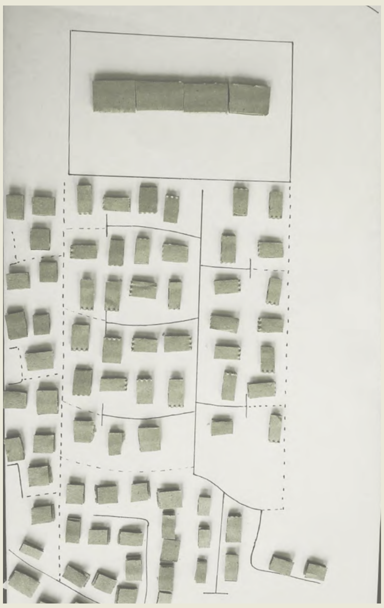
Ill. 6. Circular volume



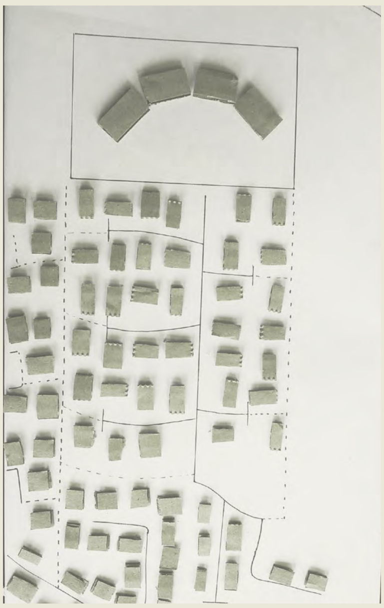
Ill. 7. Half circle volume



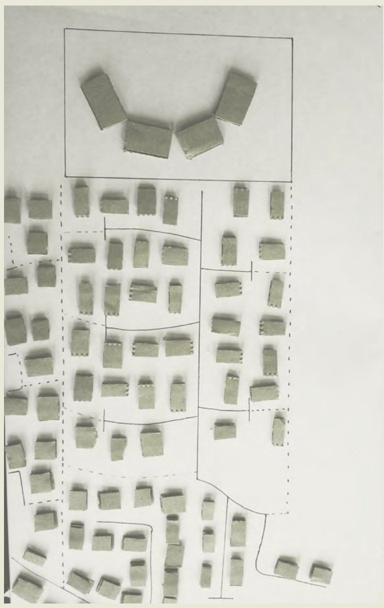
Ill. 8. Shaped circular volume



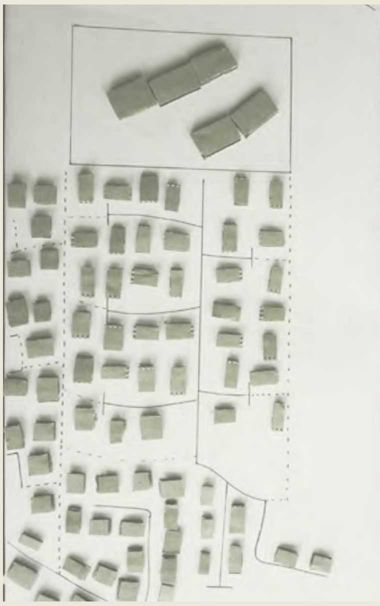
Ill. 9. Thin shape for daylight

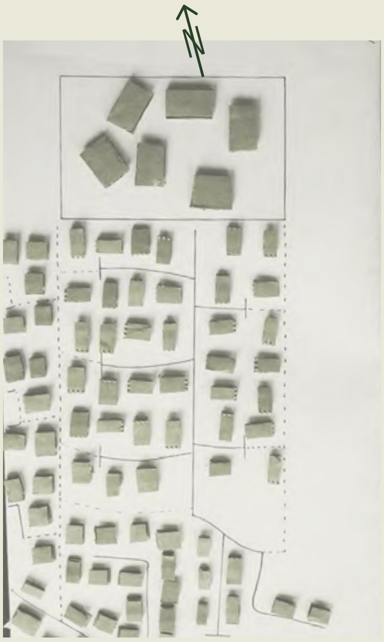


Ill. 10. Diffuse light, northern facade

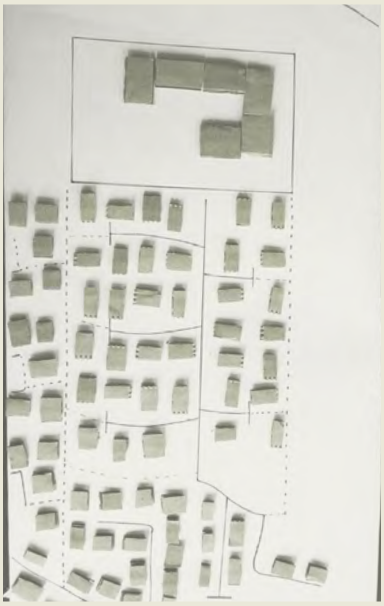


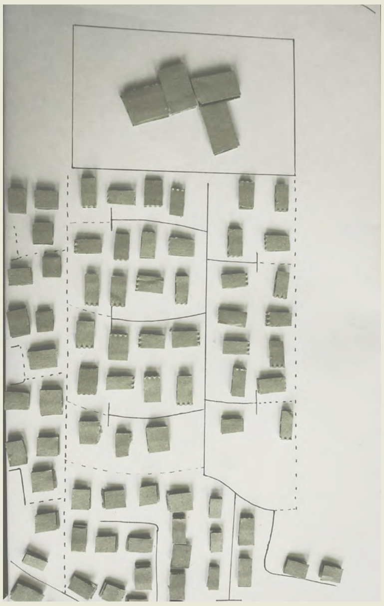
Ill. 11. Direct light, southern facade

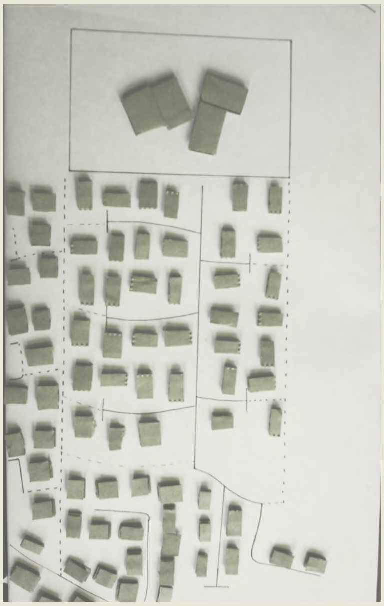

Ill. 12. Shaped for water drainage

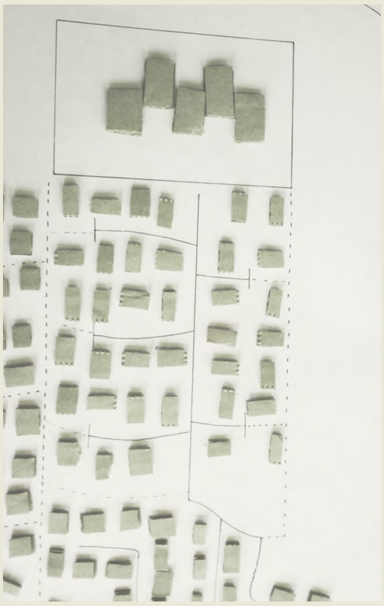


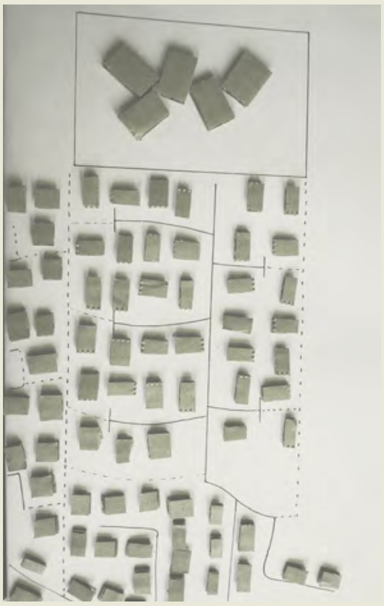
Ill. 13. Schattered volumes

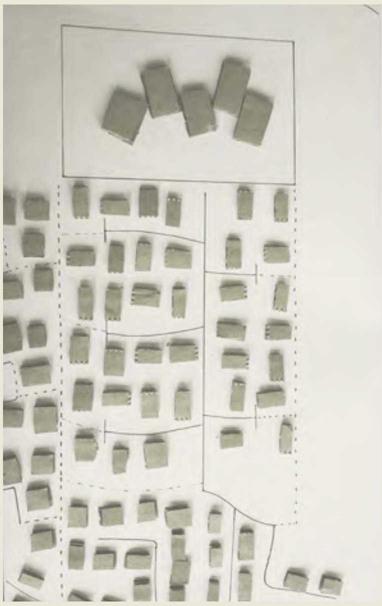

Ill. 14. Wind catching volume

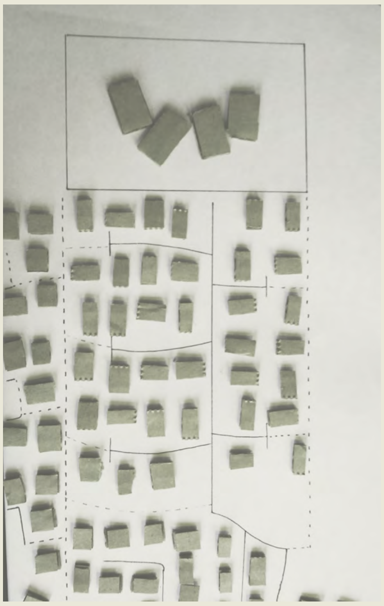

Ill. 15. Shaped for afternoon sun


Ill. 17. Split for more daylight


Ill. 19. Shiftet volumes for daylight


Ill. 16. Orientations for optimizing functions #1


Ill. 18. Orientations for optimizing functions #2


Ill. 20. Orientations for optimizing functions #3

CONCEPT DEVELOPMENT

Children

Free play

Child development

Meaningful activities

Wellbeing

Intergeneration

Sustainability

Educational play

Local community

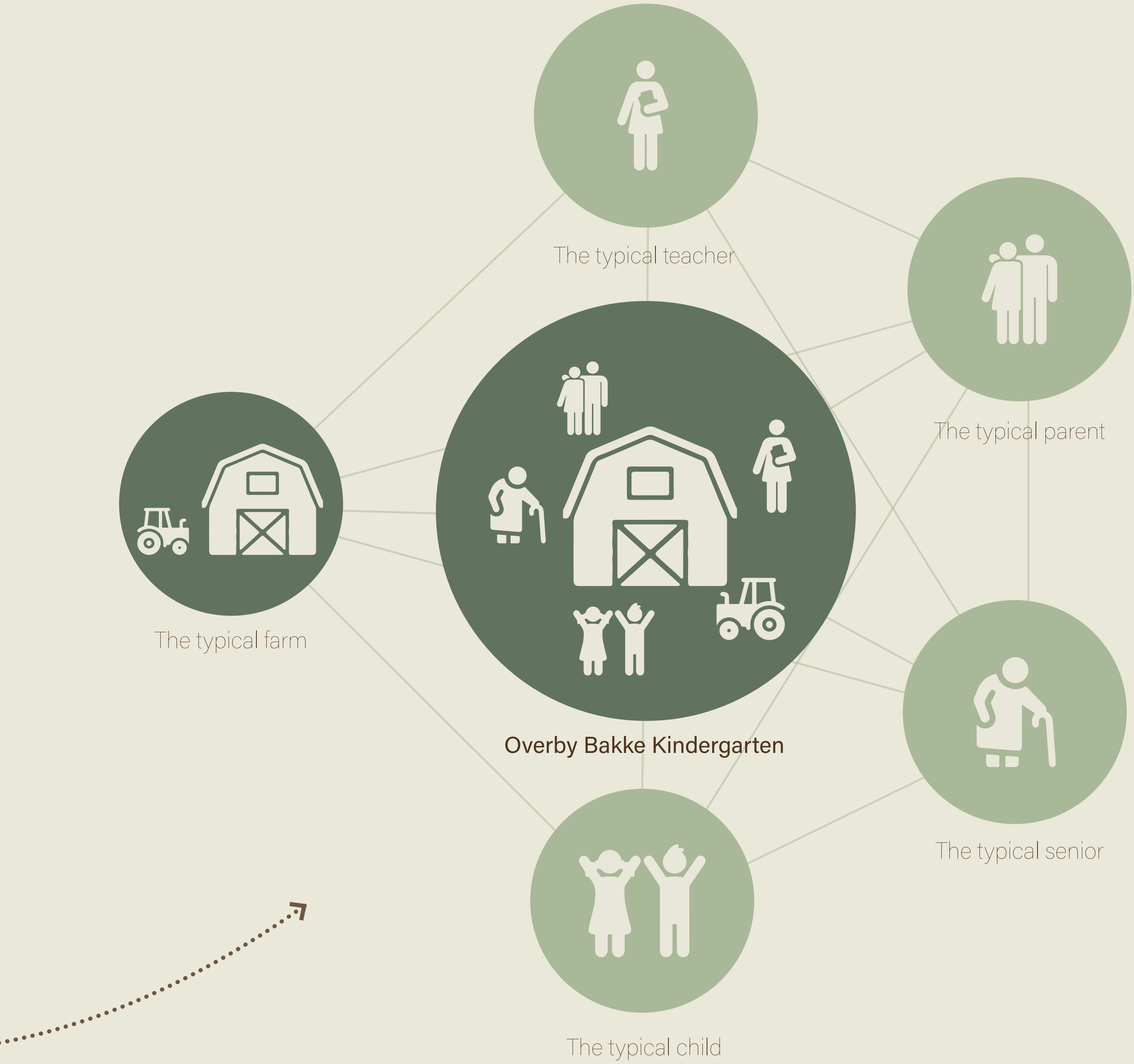
Farming qualities

Shared facilities

Atmosphere

Nature

Ill. 21. Concept mind map



Ill. 22. Initial concept idea

EVERYDAY SCENARIOS

Intergeneration

Campfire

Speed and sloped surfaces

Interaction

Water play

Ill. 23. Everyday scenarios

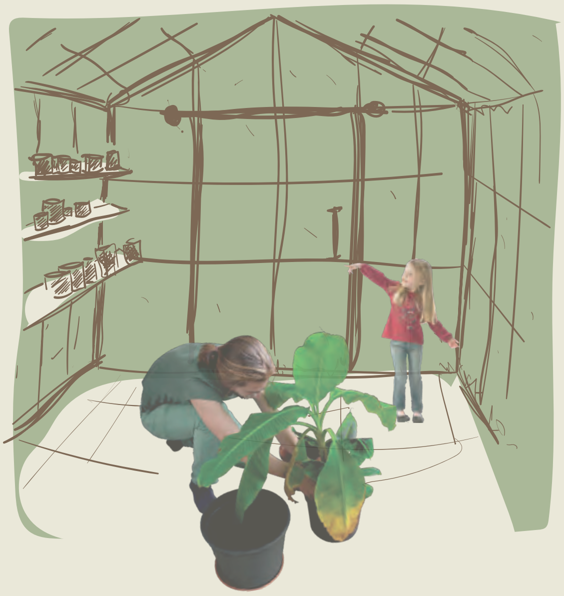
Shared kitchen

Animals

Parents flow

Child lead play

Educational activities



Ill. 24. Everyday scenarios

FARM INSPIRATION: TYPOLOGY, ELEMENTS, AND METAPHORS

Farm house

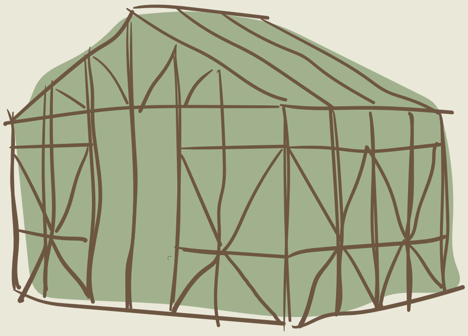
Barn

Greenhouse

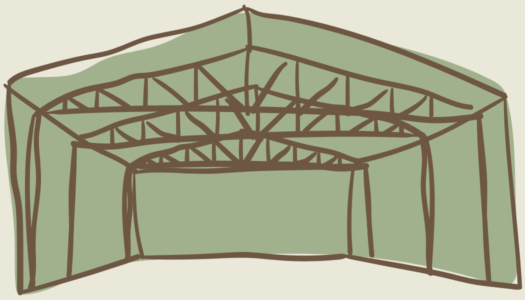
Materials and material composition

Ill. 25. Inspiration pictures from Pinterest board

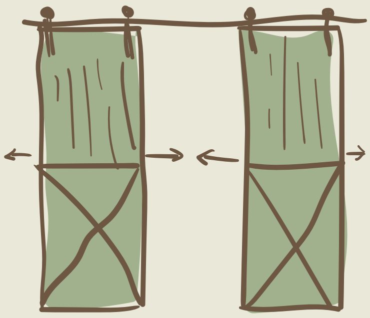
ATMOSPHERE:
FARM TYPOLOGY ELEMENTS



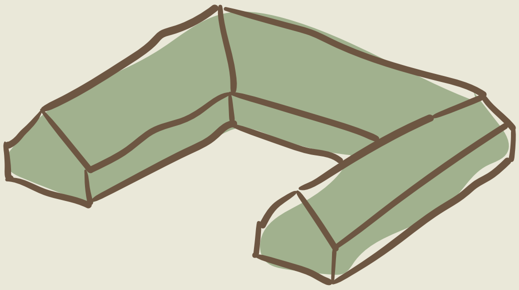
- Visible construction elements
- Half-timber structure



- Open ceiling
- Visible frame construction system



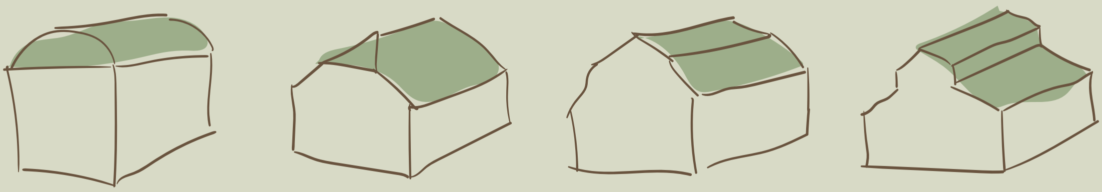
- Sliding doors



- Enclosed volume (wind protection)
- Court yard

Ill. 26. Farm typology elements

Farm typology roof design

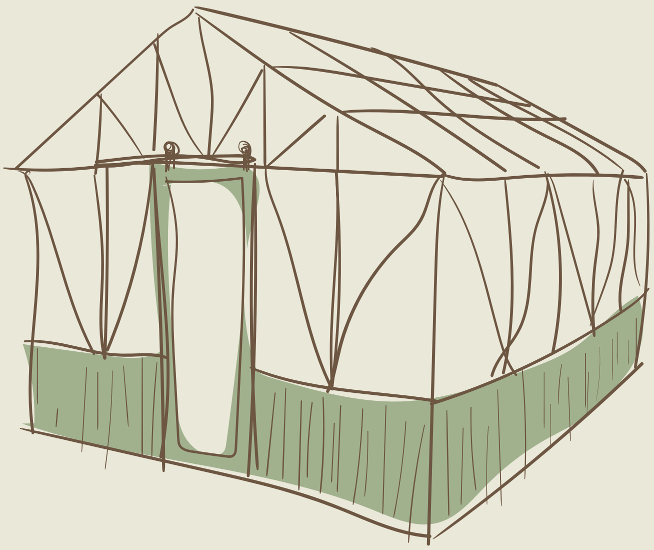


Curved roof Half hip roof Gambrel roof Double hip roof

Ill. 27. Roof typologies

DESIGN RECIPE:
FROM INSPIRATION TO DESIGN

Half timber inspired greenhouse

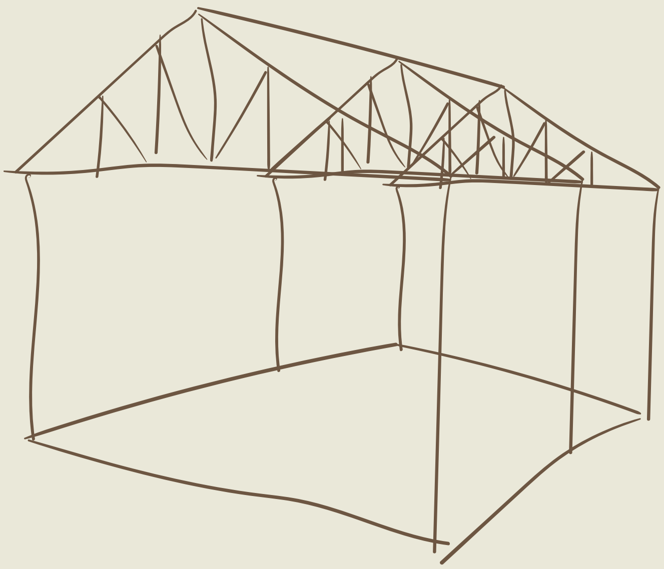


Ill. 28. Farm typology elements

Considerations:

How to avoid individual produ-
ced glass elements?
- Seperate structure and glass?
- Modulize/prefab?

Visible wooden construction elements



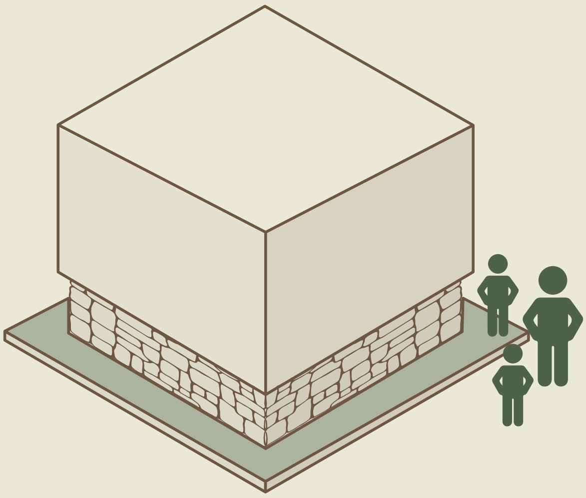
Ill. 29. Farm typology elements

Considerations:

How to make it more efficient
to construct?
- Modules?
- Prefab?
- Material waste?
- Can acoustic be a challenge?

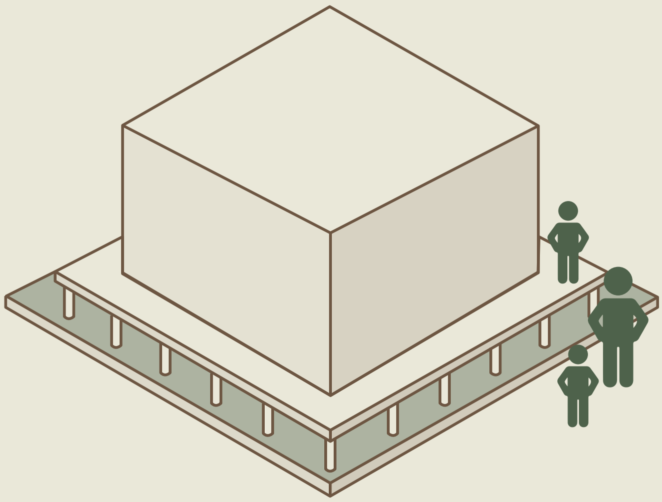
TOUCHING THE GROUND

Old-school farm



Ill. 31. Old-school farm foundation

Modern farm



Ill. 30. Modern farm foundation

Adding material

Removing material

Moving material

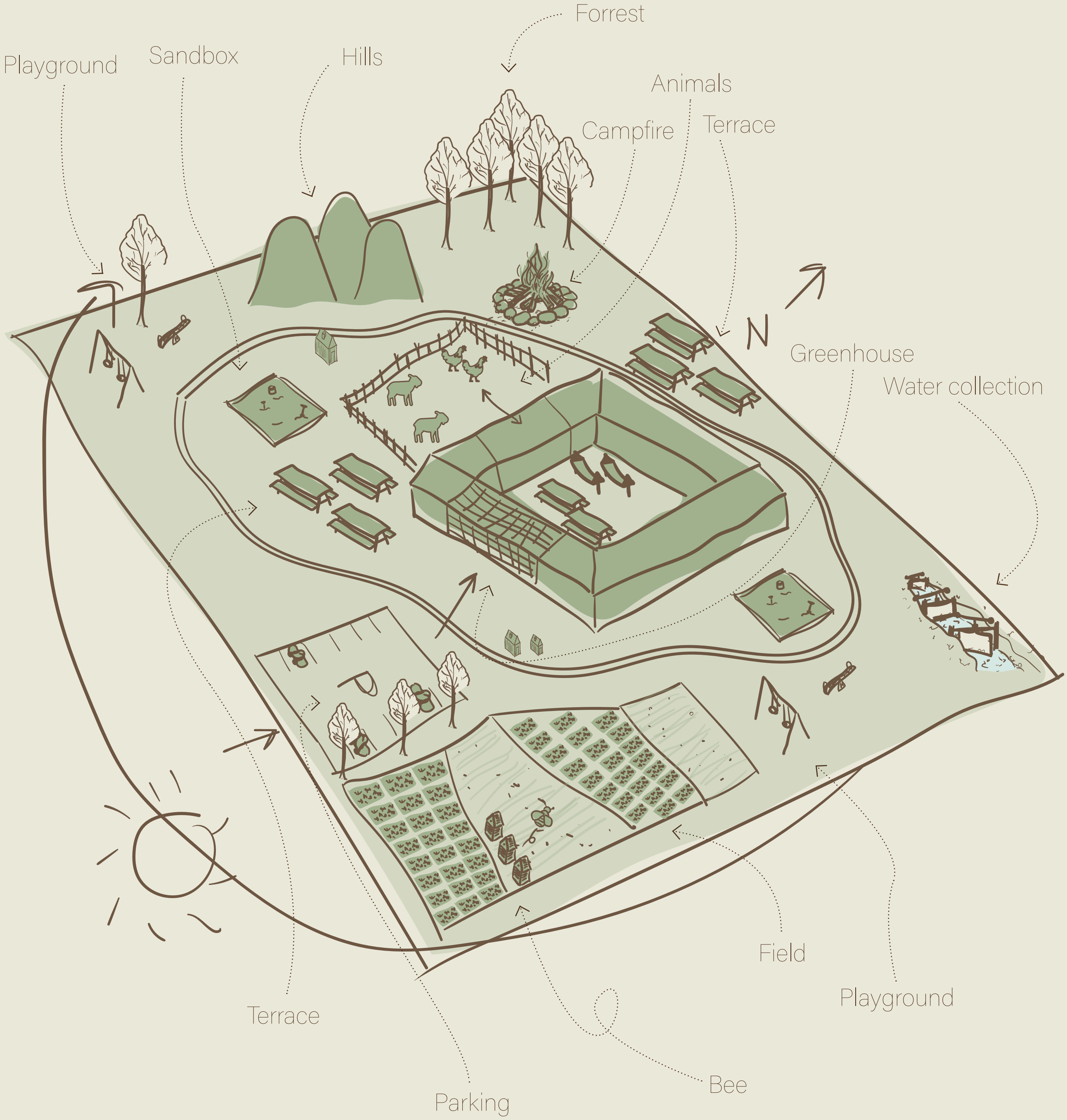
- Light expression

- Heavy expression

- Heavy expression

Ill. 32. Touching the ground - earth

CONCEPTUAL SITE PLAN 1



Ill. 33. Conceptual site plan 1

Pros:

- Greenhouse and field exploits the southern sun

- The north-eastern cornor with risk of water accumulation will be exploited for play with rain water

- Hills protect the building, animals and campfire from the western winds

- The courtyard invites quiet and focused activites such as workshops or relaxing

Cons:

- Greenhouse towards south limits the area for solar cells on the roof. Furthermore, it is preferable to place crops in a greenhouse towards the east to acheive the morning sun which heats up the space after a cold night. The crops might get burned while standing in the direct sunlight for the entire day.
What if the solar cells got integrated elsewhere?
Or should the greenhouse be moved?

- What if active strategies get visibly incoporated in the build environment as a tool to teach children about the basic elements of the earth? Wind, water, sun and earth.

- Crops are not protected from the west wind which can lead to damage.
Should the field be moved?
Is it better to create wind protection? Hills? trees?

- Smoke from campfire might pollute the inlet for ventilation during western wind.

Neutral:

- Movement between the building, playground and courtyard is limited. Better movement can be achieved by creating openings in the building volume

- Animals and greenhouse is a part of the kindergarten building volume which creates a holistic farm expression

- What if the campfire gets moved close to the water to provide security in case of excessive fire as well as adding shelters as a benefit for the kids as well as the local community?

Considerations:

- Create western wind shelter for the field

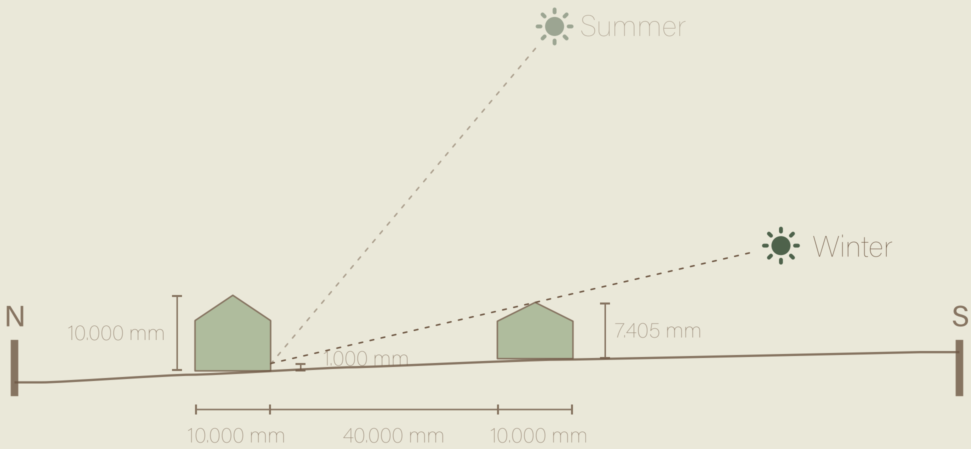
- Create openings in the building volume

- How to get the most out of active strategies? (move greenhouse)

- Move the campfire and add shelters

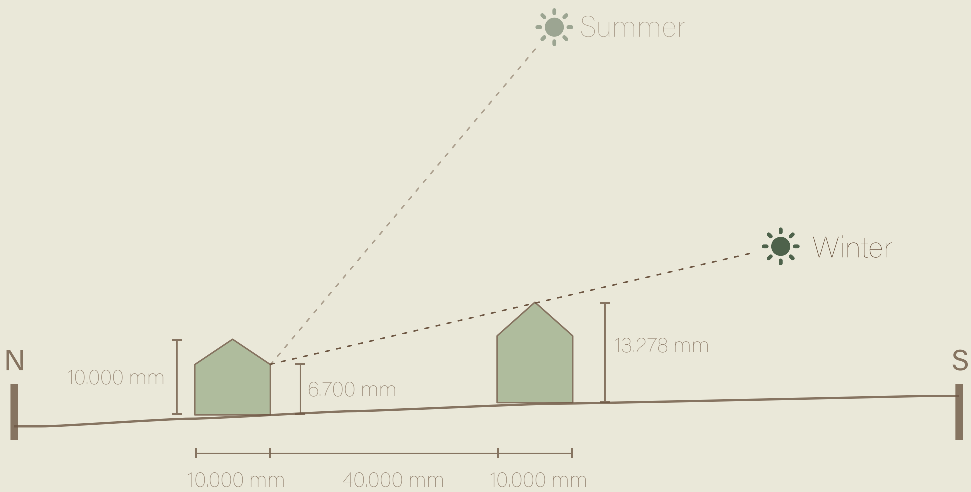
BUILDING VOLUME ACCORDING TO SUN ANGLE

Achieving at least one hour of direct sun each day during the entire year



Ill. 34. Sun angle diagram for achieveing at least one hour of direct sun each day during the entire year

Solar cells on northern building volume



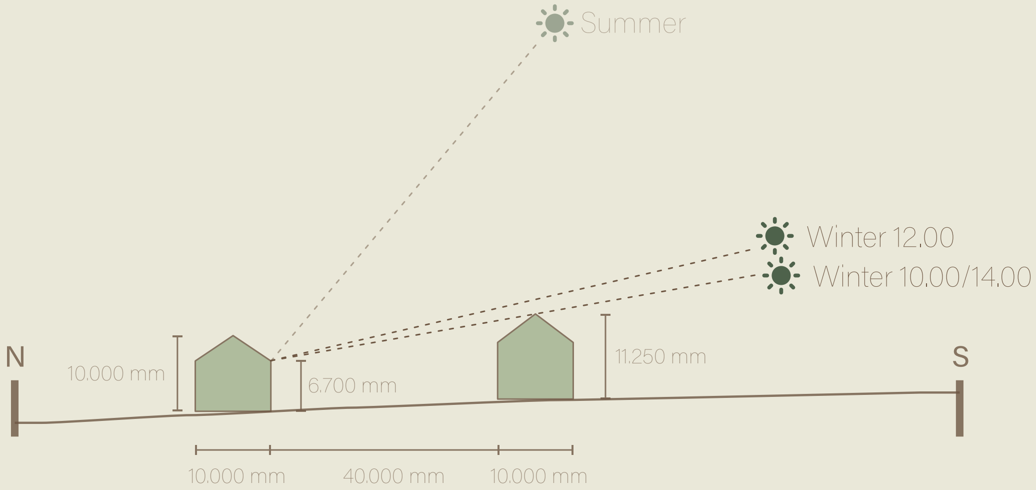
Ill. 35. Sun angle diagram for the possibility of solar cells on the northern building volume

Considerations:

- How to take the winter sun into consideration for an entire day when the illustrated 13 degree angle represent the greatest sun angle at winter solstice (12.00)?

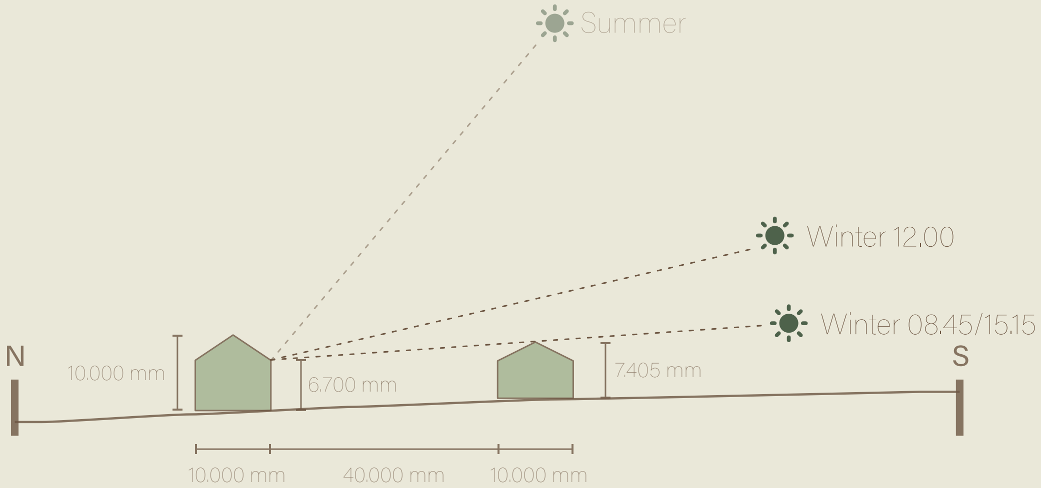
BUILDING VOLUME ACCORDING TO SUN ANGLE

Building height to achieve at least 4 hours of direct sun on the roof on a winter day



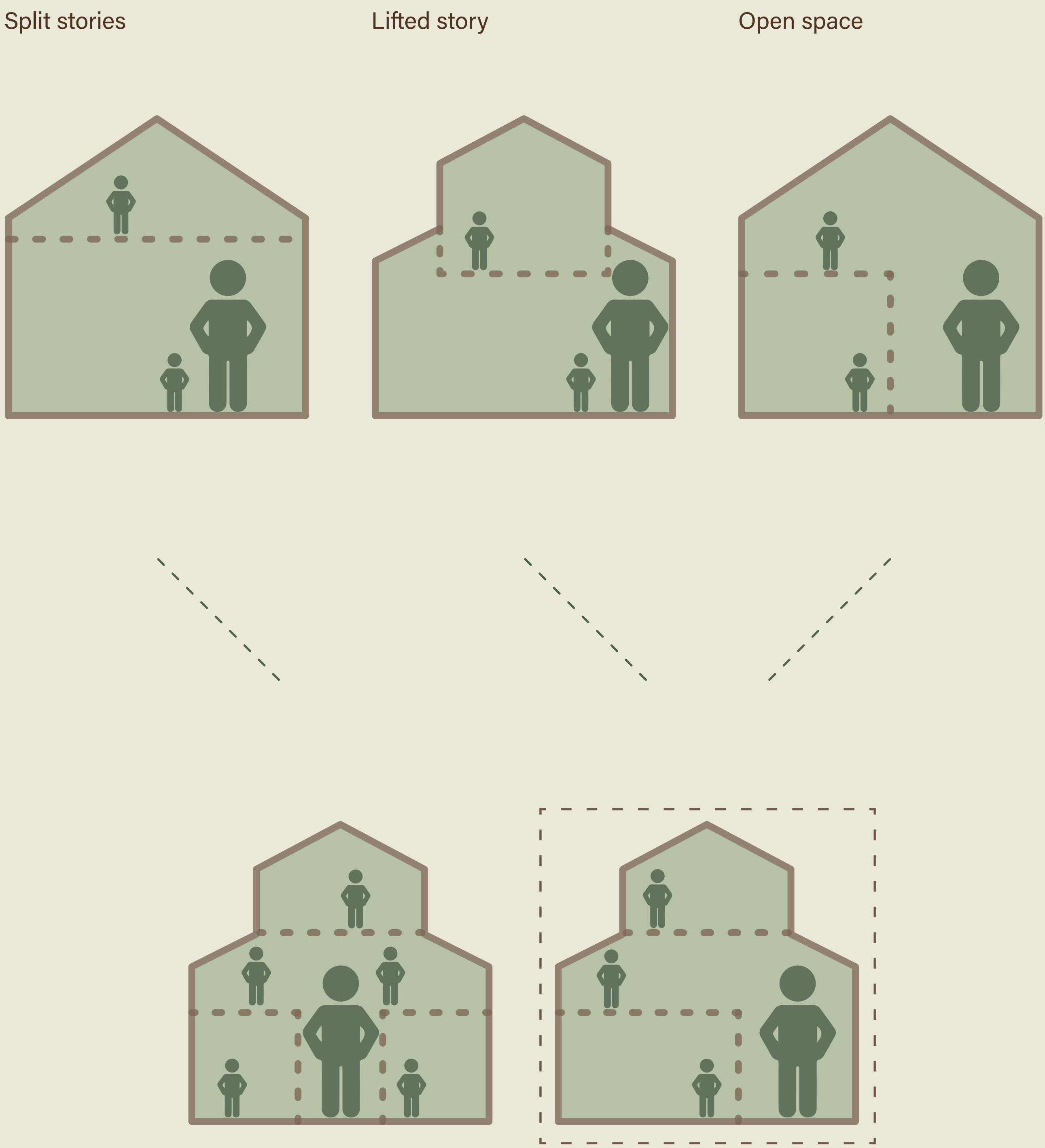
Ill. 36. Sun angle diagram for achieveing at least four hour of direct sun each day on the roof, during the entire year

Building height to achieve at least 6.5 hours of direct sun on the roof a day as well as achieving at least one hour of direct sun inside the building a day each year



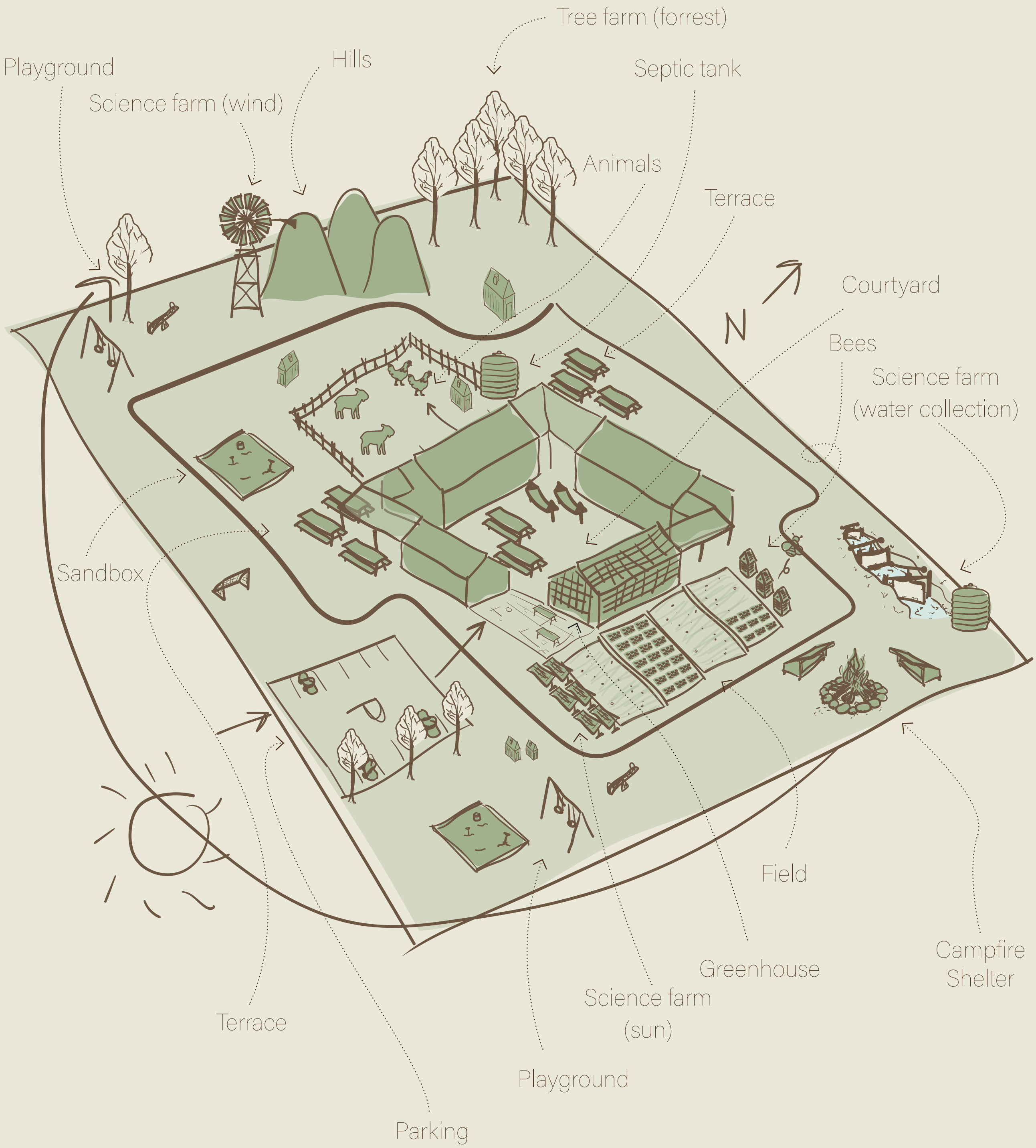
Ill. 37. Sun angle diagram for achieveing at least one hour of direct interior sun each day, during the entire year

HUMAN SCALE

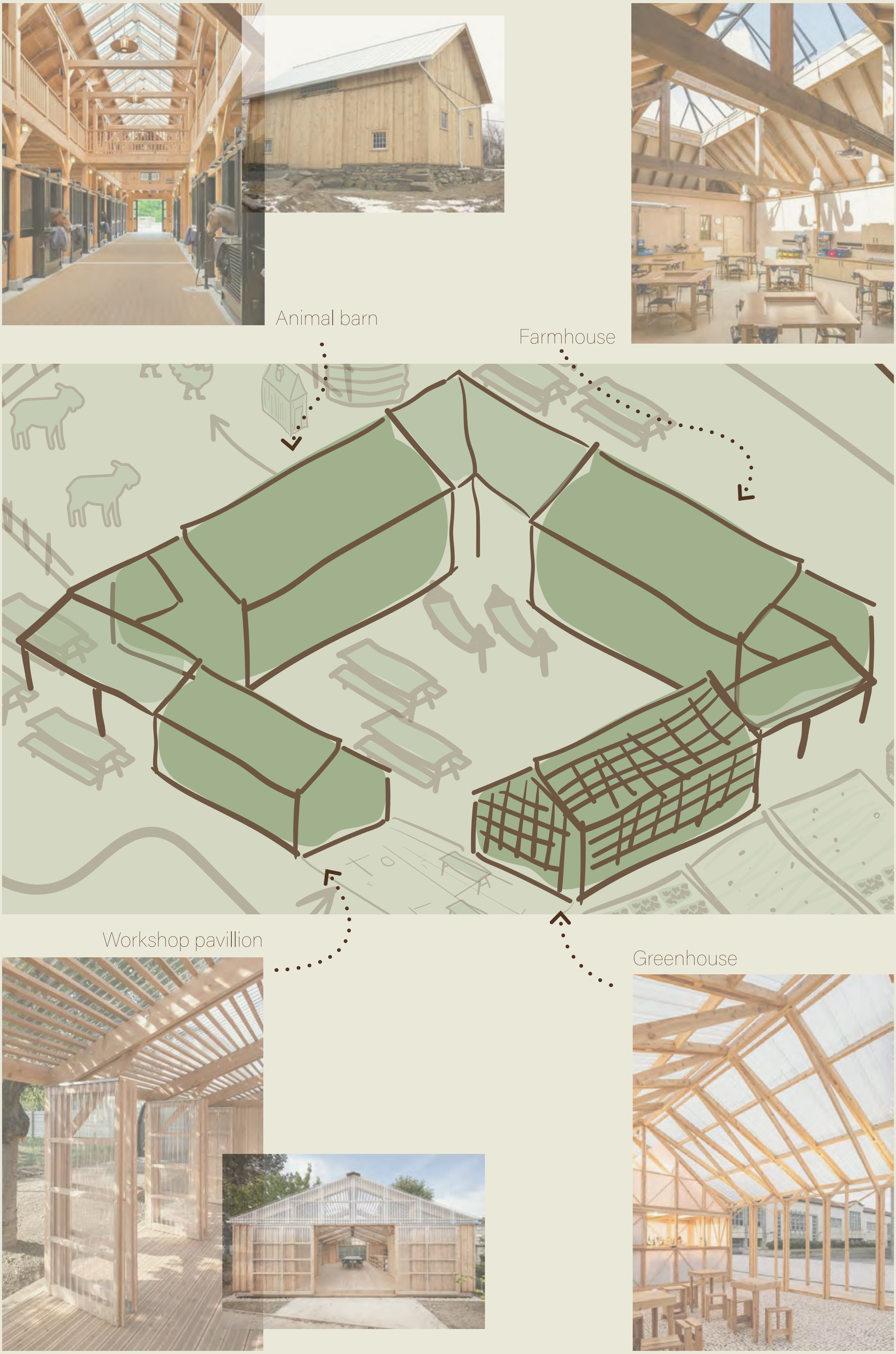


Ill. 38. Spaces within spaces according to room height

CONCEPTUAL SITE PLAN 2



Ill. 39. Conceptual site plan 2



Ill. 40. Conceptual site plan 2 - building inspiration

BUILDING PLACEMENT
SUN AND SHADOW SIMULATION

Winter solstice

9.00

12.00

15.00

Equinox

9.00

12.00

15.00

Summer solstice

9.00

12.00

15.00

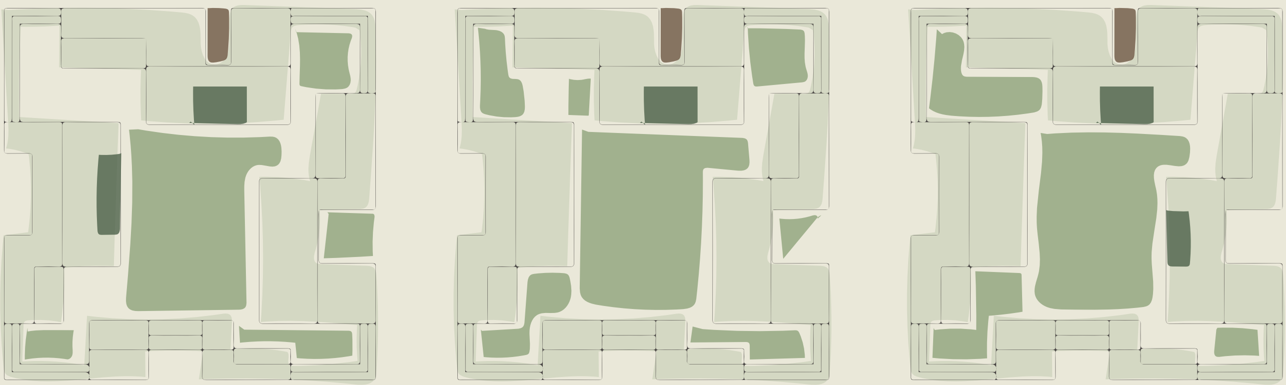
Ill. 41. Shadow investigation

DAILY USAGE OF COURTYARD

Optimized for sun

Not optimized for sun

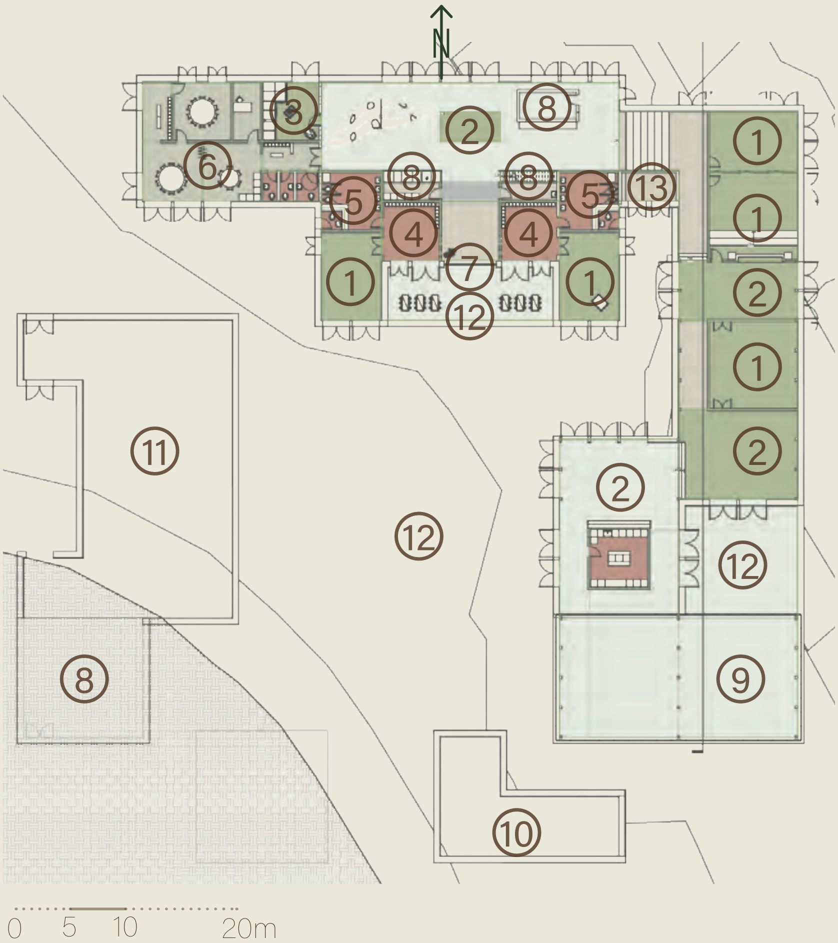
Could be optimized for sun



Morning | Lunch | Afternoon

Ill. 42. Shadow investigation - evaluation

ADDING SCALE TO THE BUILDING

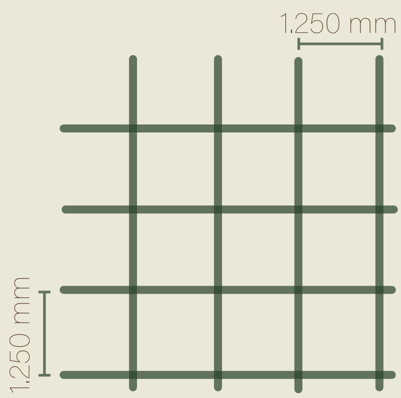


1	Playroom
2	Common room
3	Sleeping
4	Wardrobe
5	Toilet
6	Staff area
7	Entrance
8	Storage
9	Greenhouse
10	Workshop
11	Animal barn
12	Courtyard
13	Technical

Ill. 43. Plan first iteration

A grid system has been made prior to adding measures to the plan.
It is normally used by structural or MEP engineers when determining the structural and ventilating system. The grid will ensure those elements are not clashing. In this project the grid will act as a connection between architecture and engineering since the grid system is a guideline to place walls, doors windows ect. to ensure the architectural elements do not clash with engineering systems.

No construction method or components have been decided in this stage of the design process. But adding a grid system this early, makes it possible to design for modules or prefabrication, with faster and cheaper construction due to repetitive measurements. When following the gridline, placement of windows does not interfer with structural elements, walls, ect.



DESIGNING FURTHER IN VIRTUAL REALITY BASED ON AFFORDANCES

Ill. 44. Entrance double storey ceiling

Ill. 45. Entrance single storey ceiling with niches in child scale

Ill. 46. Entrance affords play

Ill. 47. Pillow room acting as sleeping room

Ill. 48. Visible structure and skylights

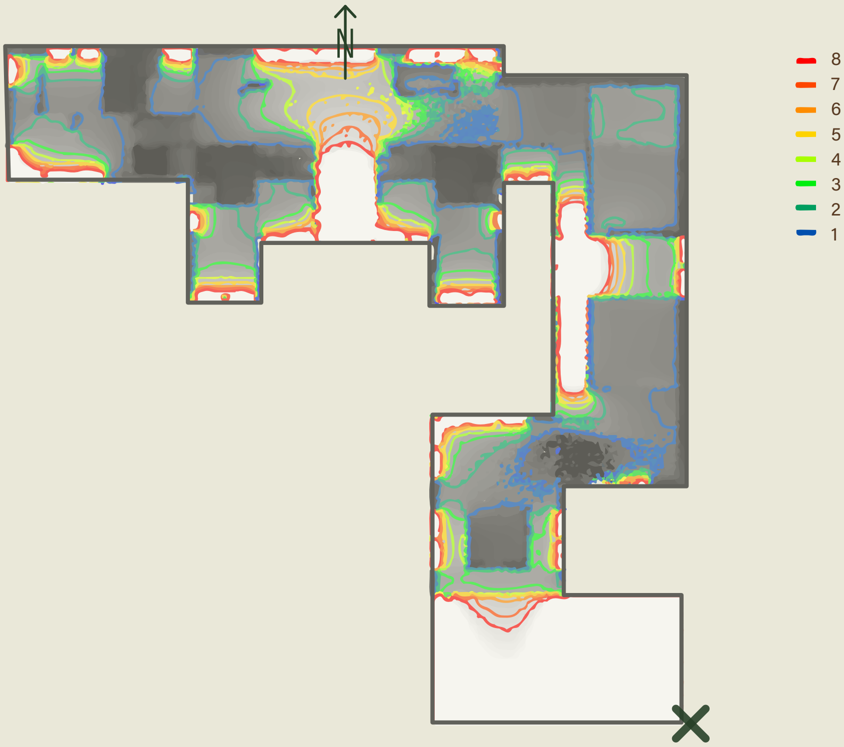
Ill. 49. Improving daylight by adding interior windows

Ill. 50. Greenhouse

Initial daylight analysis

Daylight factor average 2-3%

Not optimal difference between the light quality in different rooms

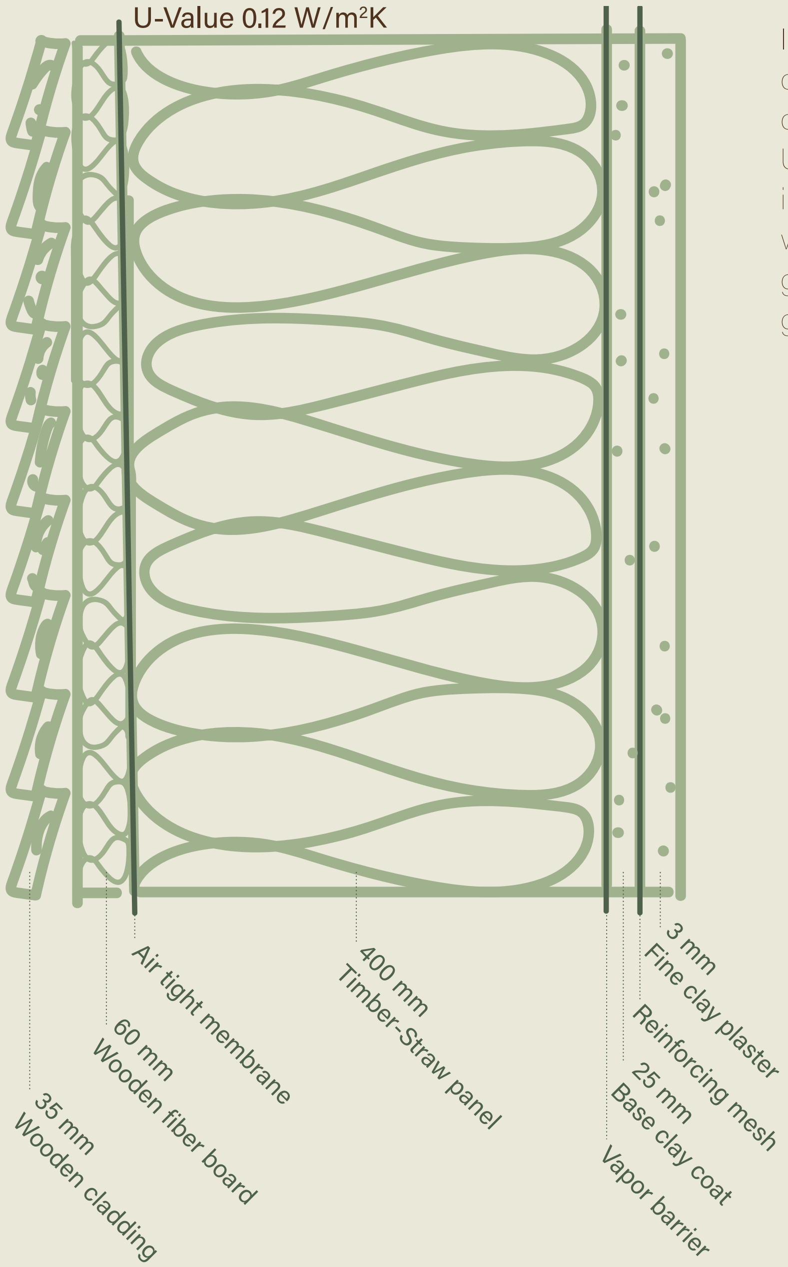


Ill. 51. Daylight analysis

ENERGY CONSUMPTION

Estimated energy consumption
(calculated with BE18)

20,6 kWh/m² year



Implementing energy calculations as a tool to validate design options.
Updating the calculation daily creates and awareness of which design elements has greatest infuence on the energy consumption

Ill. 52. Wall structure - implementing EcoCocon straw elements (EcoCocon, 2021)

MIDTERM REVIEW
TURNING POINT OF SKETCHING

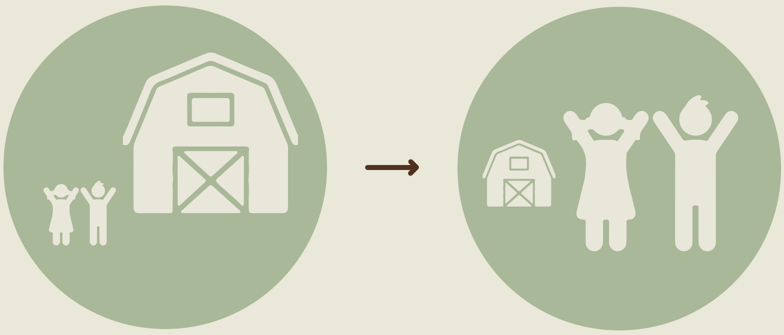
The integrated design process has not been taken much into consideration up until the midterm review which resulted in a design which has not been reviewed enough by all phases back and forth. Preparations to the synthesis phase have been made until this point from the mindset to move from the sketching phase to the synthesis phase afterwards.

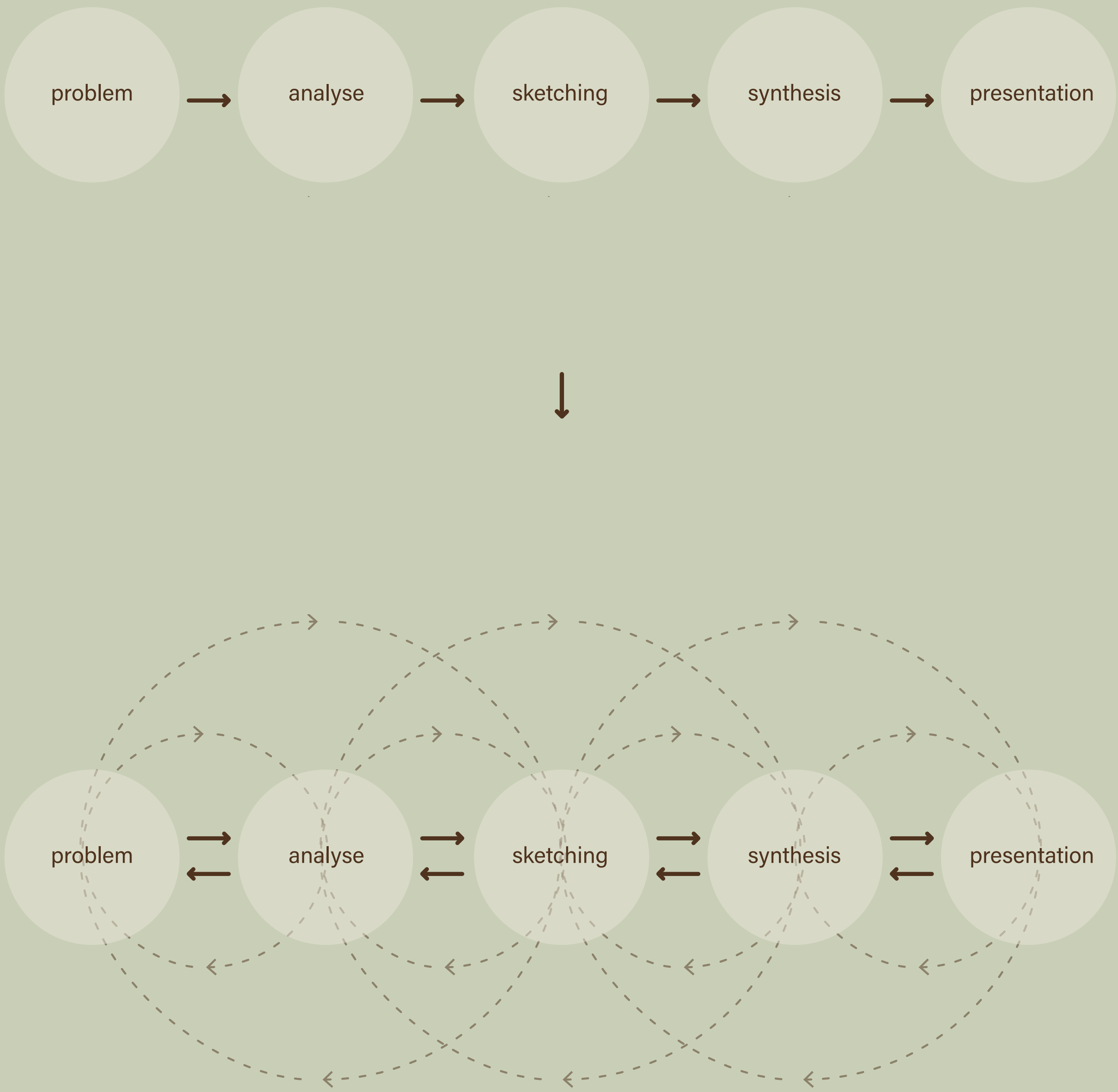
It was valuable to get constructive comments on the design from supervisors' perspective who have never seen this project before. The midterm review turned out to act as a tool to point out the importance of reviewing the project and design with a new mindset as well as revisit conclusions from the program, design criteria and objectives to create different iterations in the sketching phase.

The question "What is a good kindergarten?" asked in the problem statement is an important thought to have in mind in the process of taking a step back and reviewing the design. This question made a realization of the concept being interpreted from a wrong standpoint. The building is trying to be both a kindergarten and a farm without taking contradictions into consideration. The typology turned out to be neither of the two after going through the progression of the sketching phase.

The new goal is to make a kindergarten with the qualities of a farm NOT a farm which also suits a kindergarten.

Going forward timed workshops will be conducted. Goals, questions, or design element will individually be considered during a time span between 30 and 90 minutes allowing ideas and creativity to form from one element at a time instead of taking all elements into consideration at once.
The workshops act as a method to improve the creative process by allowing all ideas to be discussed while making decisions – why it is important to have an open mindset by using the workshop as a blank canvas. It is also important to be open towards major changes in the design.
Furthermore, it will actively create awareness about what is important to the concept and design in the design process, when the different topics of the workshops are being determined.

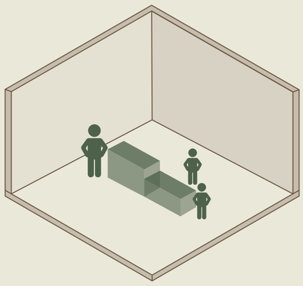




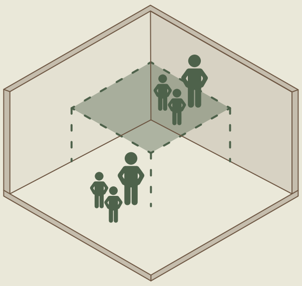
Ill. 53. Integrated design process considerations

WORKSHOP DESIGN FOCUS

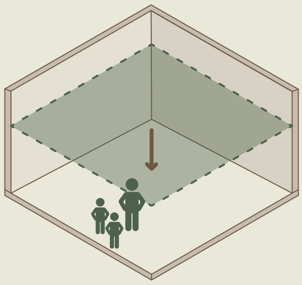
Human scale and children scale



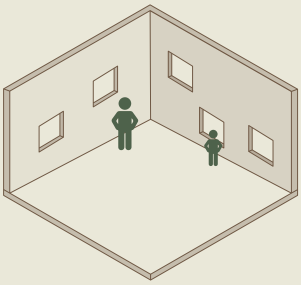
Adjustable surfaces
- Affords interaction
- Supports comfort



Repos
- Creating niches
- Breaking up the volumes
- Affords interaction, curiosity and movement



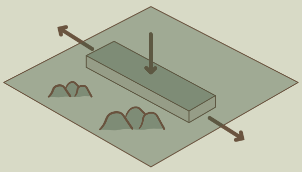
Low ceiling height
- Adjusting the room scale
- Volume supports children scale

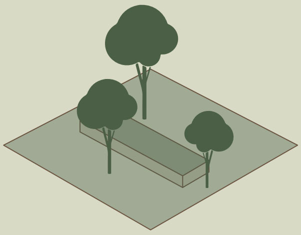


Ill. 54. Human scale diagrams

Ajdustable windows
- Affords interaction, curiosity and movement
- Provides comfort

Atmosphere and landscape



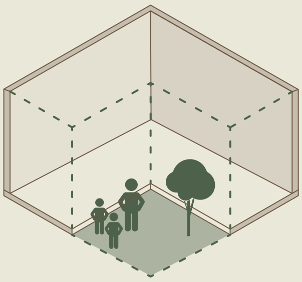


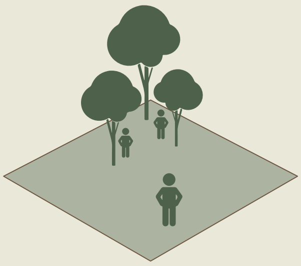
Ill. 55. Atmosphere and landscape diagrams

Adjusting to the landscape
- Green roof blending with landscape
- Low and slender building volume

Respect the landscape
- Preserve trees and other types of nature
- Allowing growth biodiversity (insects)

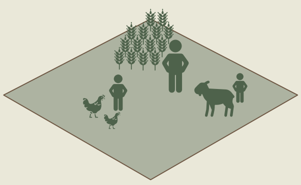
Farming qualities

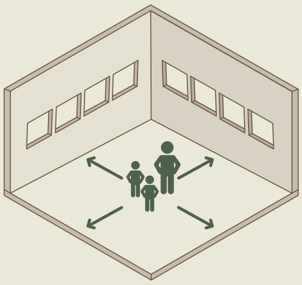




Courtyards
- Enclosed / protected space
- Gathering point and central meeting place
- Protected against wind

Outdoor spaces
- Ability to investigate new areas, get lost and hide
- Plenty of land
- Playing and interacting with nature such as water or mud





Ill. 56. Farming qualities diagrams

Farming
- Producing crops
- Having animals

Form follows function
- Affordable and simple construction
- Room program follows flow

WORKSHOP
FORM FOLLOWS FUNCTION
CONCEPTUAL SITE PLAN 3

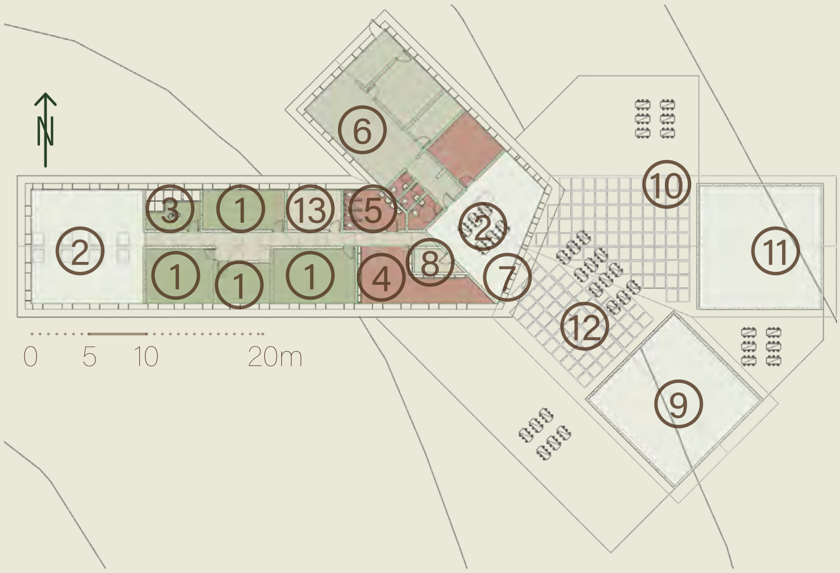
Placing outdoor functions
- *Orientation (sun and shadow)*
- *Form follows function*
- *Exterior determines where to place building volume*

Placing building according to exterior
- *Staff area with diffuse northern light*
- *Playrooms ect. with both northern and southern light*
- *Greenhouse with direct sunlight and access to fields*
- *Animal barn connected to animals*
- *Quality of the courtyard joining the different functions*

Adjusting building according to function
- *Staff area and children area is merged together and perceived as a single volume*
- *A gap between animal barn, greenhouse and main building to create a courtyard accessible from both interior and exterior*
- *Adding pathways for exterior to join functions together*

Ill. 57.   Conceptual site plan 3 - design flow

PLAN DEVLOPMENT



Ill. 58. *Plan based on conceptual site plan*

1	Playroom
2	Common room
3	Sleeping
4	Wardrobe
5	Toilet
6	Staff area
7	Entrance
8	Storage
9	Greenhouse
10	Workshop
11	Animal barn
12	Courtyard
13	Technical

Energy consumption
(calculated with BE18)

24,2 kWh/m² year ↑

Considerations

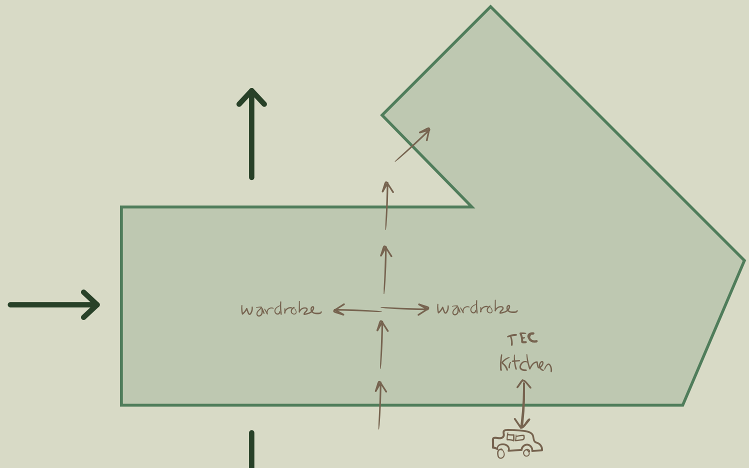
- Two wardrobes instead of one

- New main entrance to wardrobes utilized for children and parents. Beneficial for flow and cleaning

- Secondary entrance to the common room

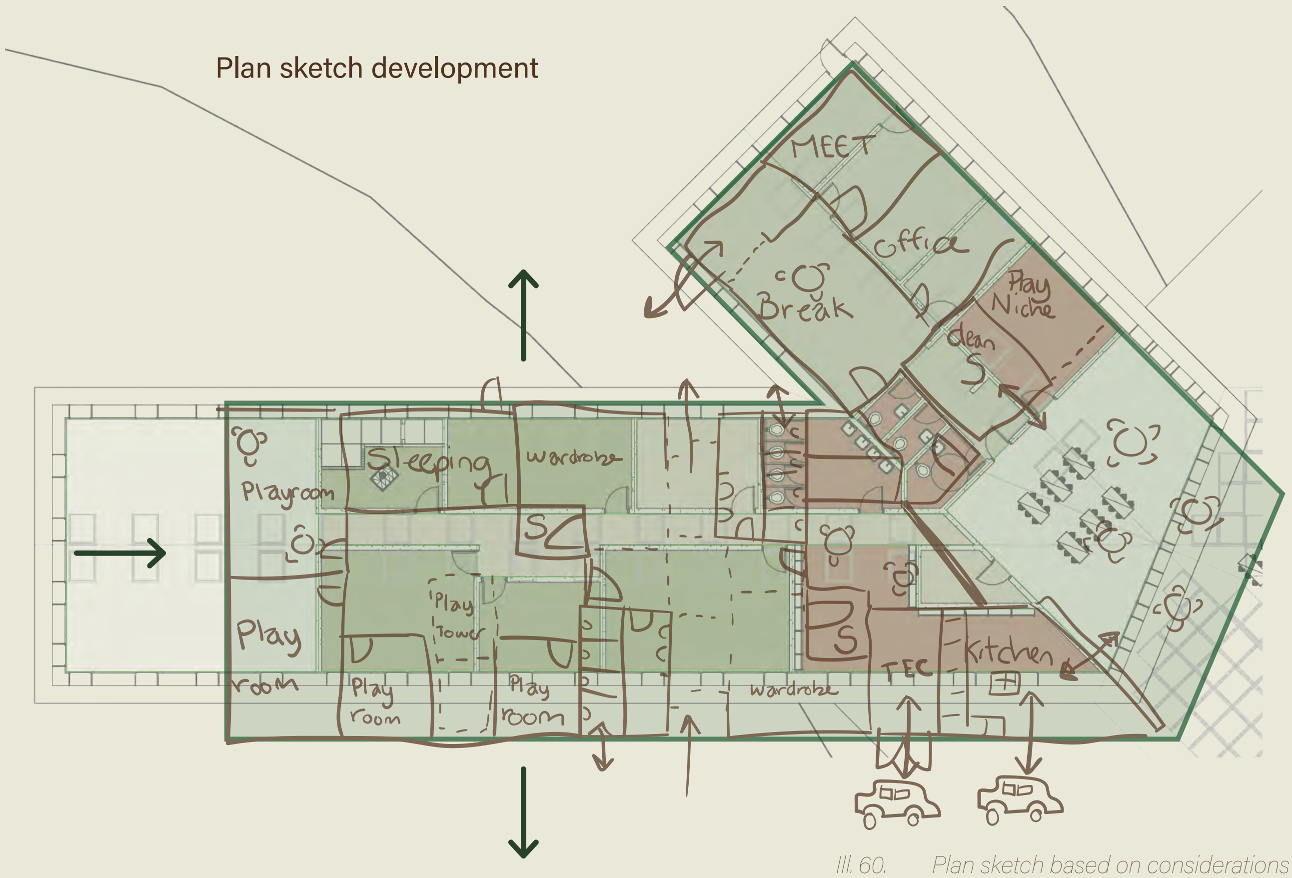
- Consider delivery to kitchen and technical room when the arriving point is from south

- Increase hallway for functionality



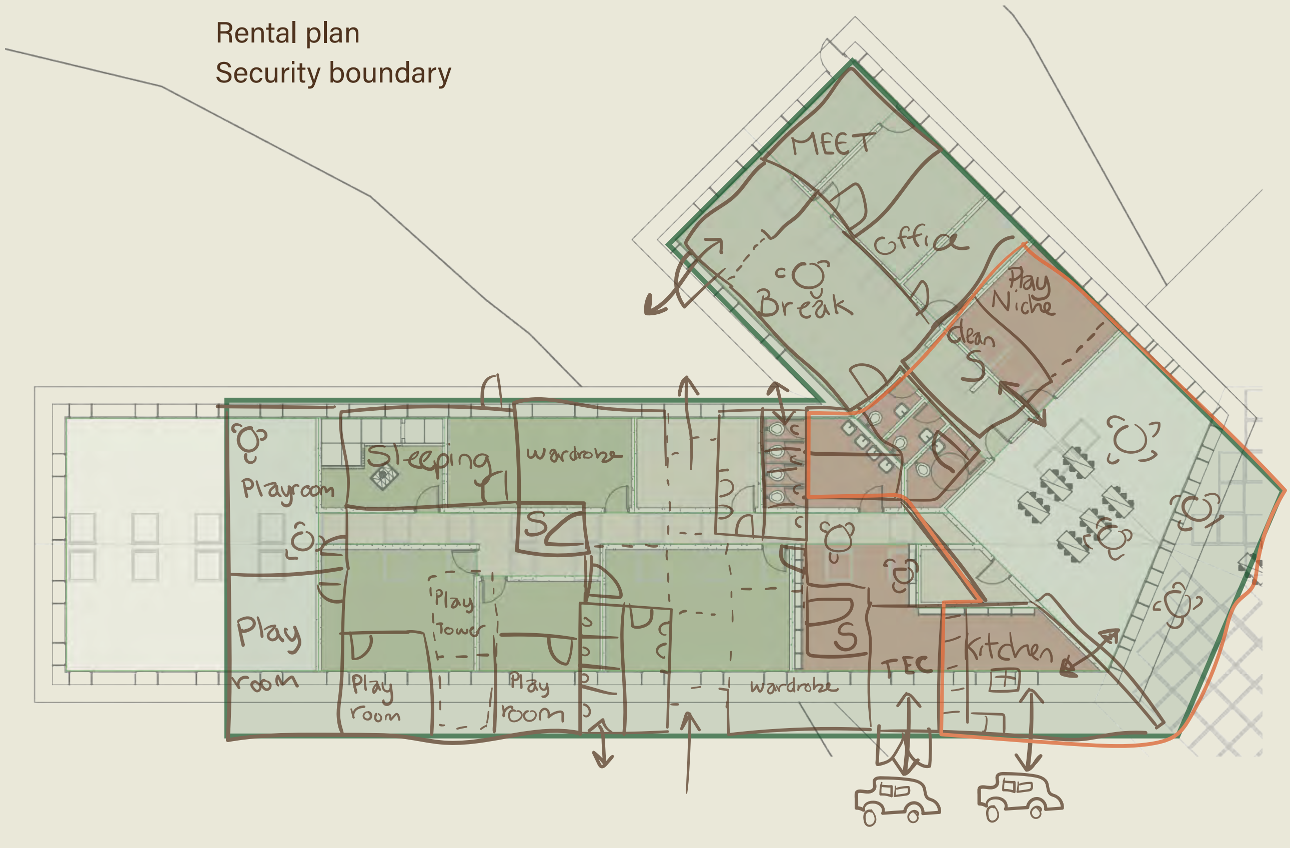
Ill. 59. *Considerations visualized*

Plan sketch development

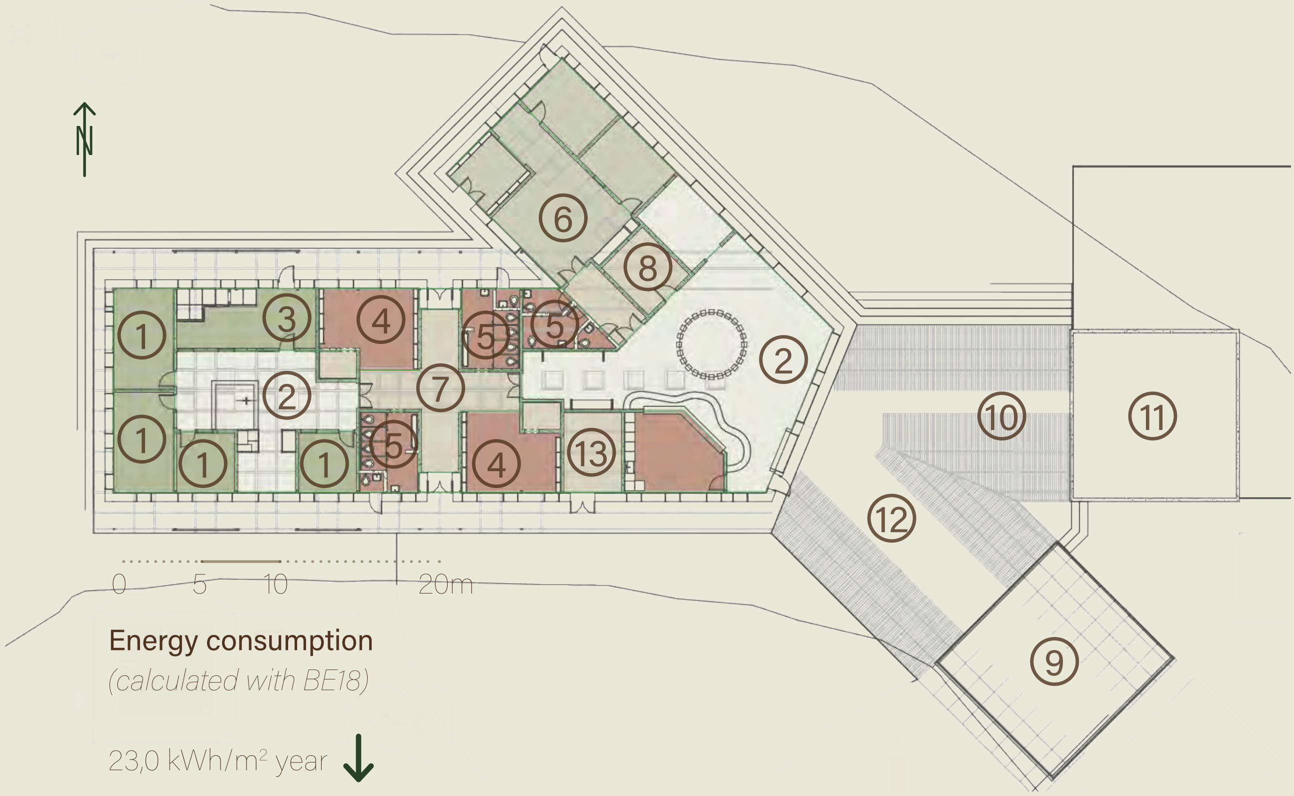


Ill. 60. Plan sketch based on considerations

Rental plan
Security boundary



Ill. 61. Security boundary plan sketch



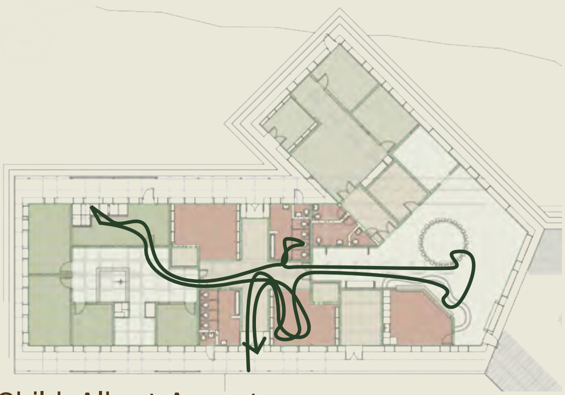
Energy consumption
(calculated with BE18)

23,0 kWh/m² year ↓

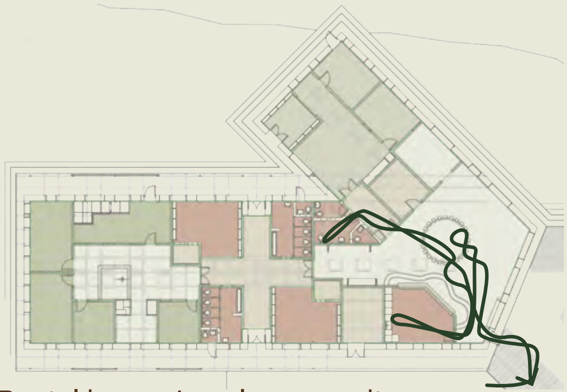
Ill. 62. Plan based on considerations

1	Playroom
2	Common room
3	Sleeping
4	Wardrobe
5	Toilet
6	Staff area
7	Entrance
8	Storage
9	Greenhouse
10	Workshop
11	Animal barn
12	Courtyard
13	Technical

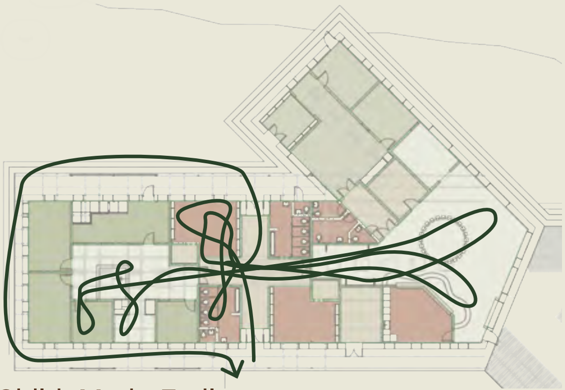
INTERIOR FLOW PERSONA



Child: Albert-August

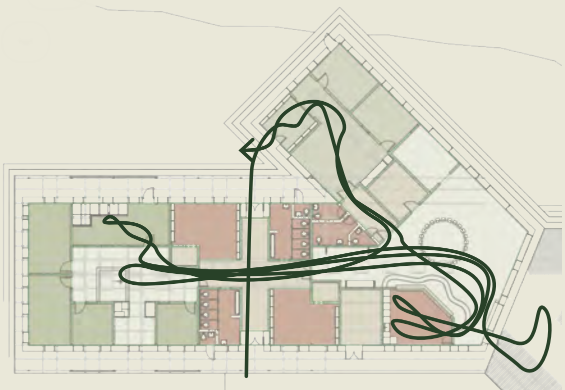


Rental hours: Local community



Child: Mads-Emil

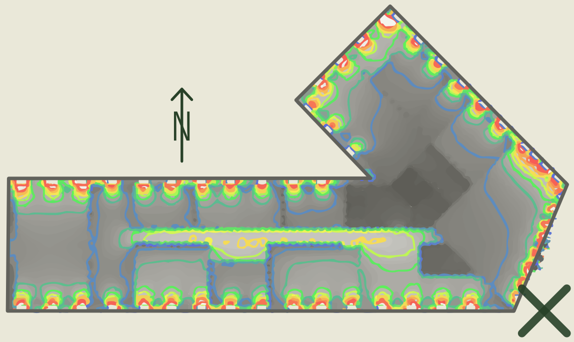
Parent: Charlotte



Teacher: John

Ill. 63. Flow based on personas

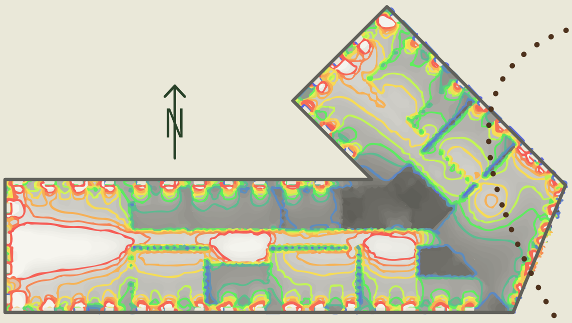
ANALYTICAL EVALUATION



Initial analysis: *Less than 1.5 % average*

Energy consumption
(calculated with BE18)

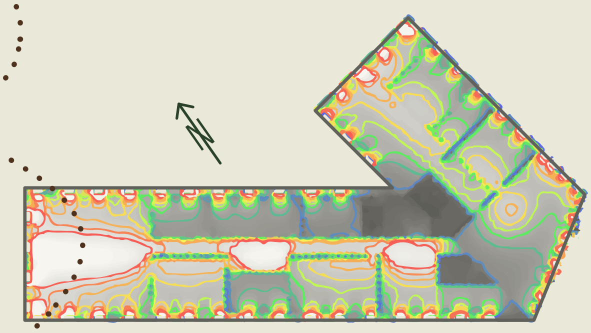
27.2 kWh/m² year ↑



Adjusting windows and skylight: *Optimal*

Energy consumption
(calculated with BE18)

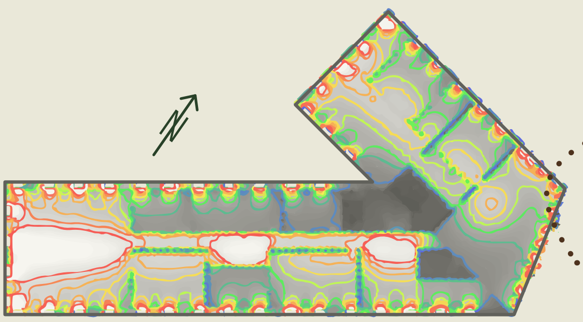
24.2 kWh/m² year ↓



Testing orientation 35º: *Optimal*

Energy consumption
(calculated with BE18)

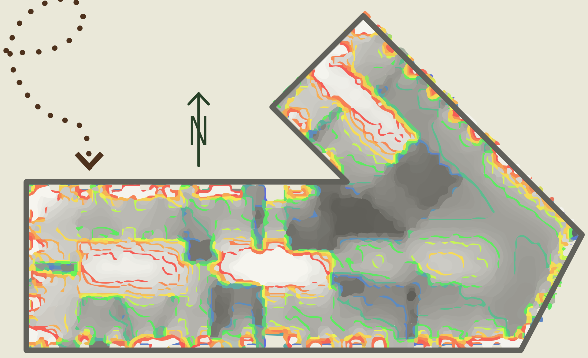
25.1 kWh/m² year ↑



Testing orientation -35º: *Optimal*

Energy consumption
(calculated with BE18)

24.7 kWh/m² year ↑



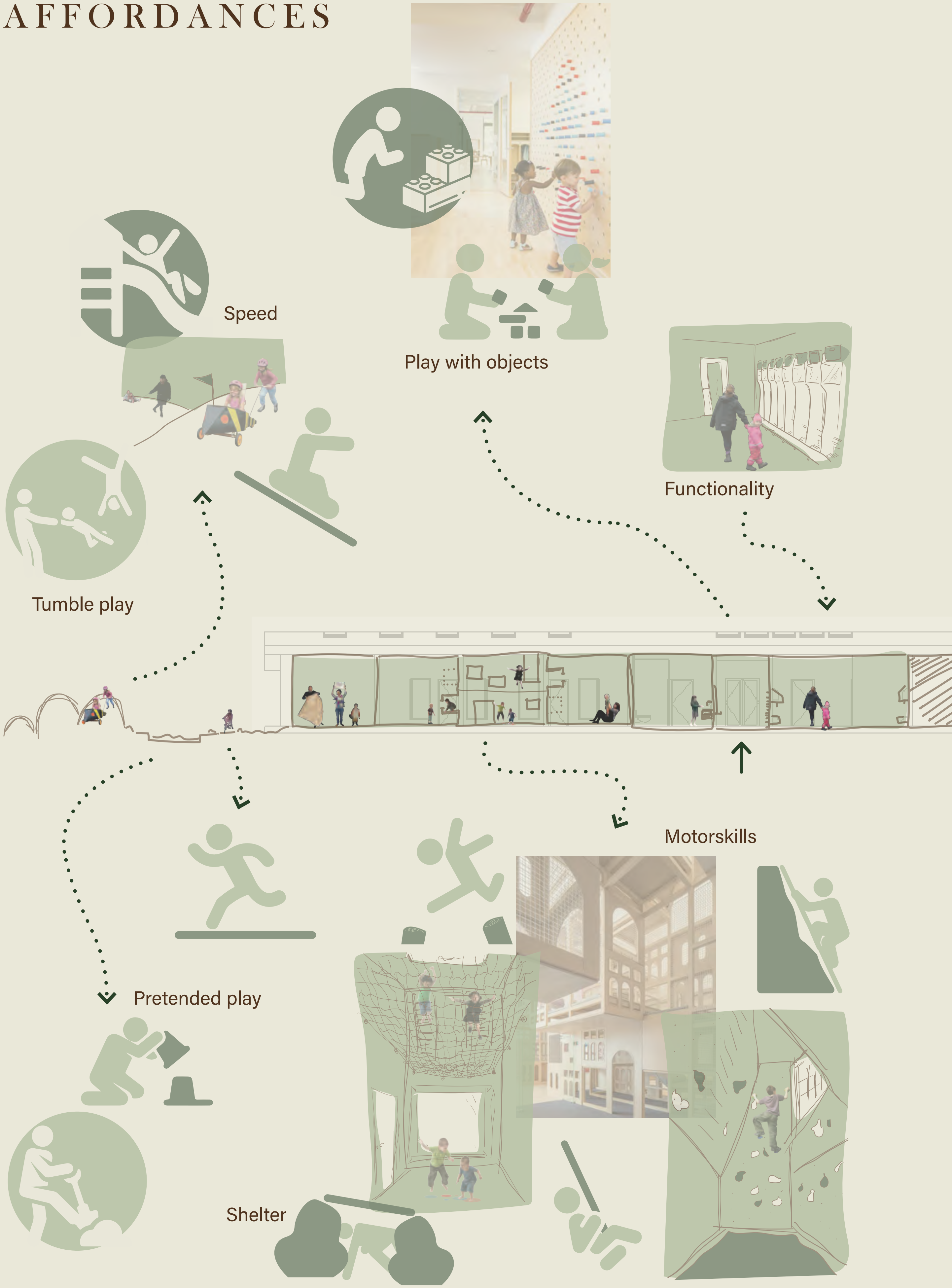
Adjusting volume with similar strategies: *Optimal*

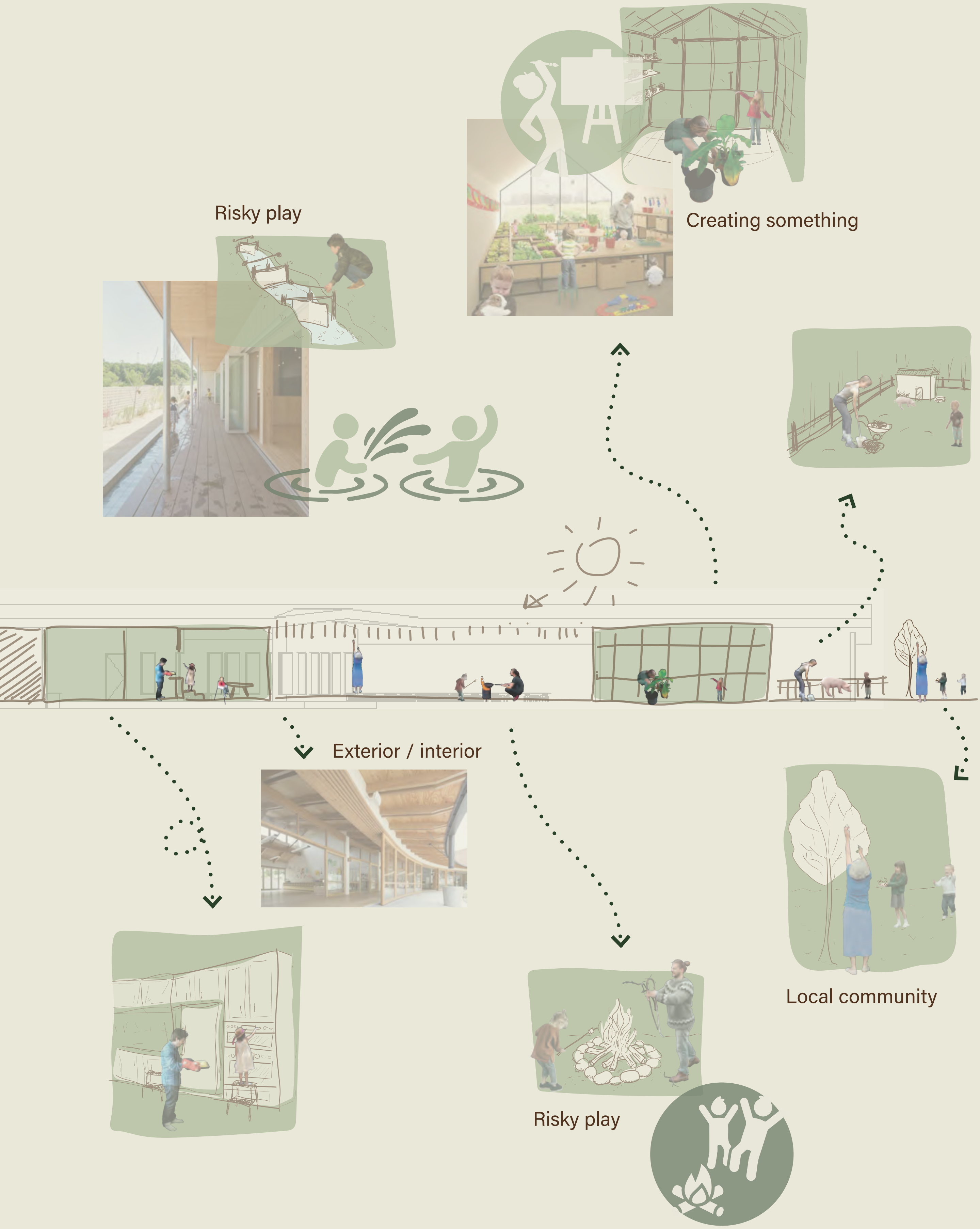
Energy consumption
(calculated with BE18)

23.0 kWh/m² year ↓

Ill. 64. Daylight and energy calculations

AFFORDANCES

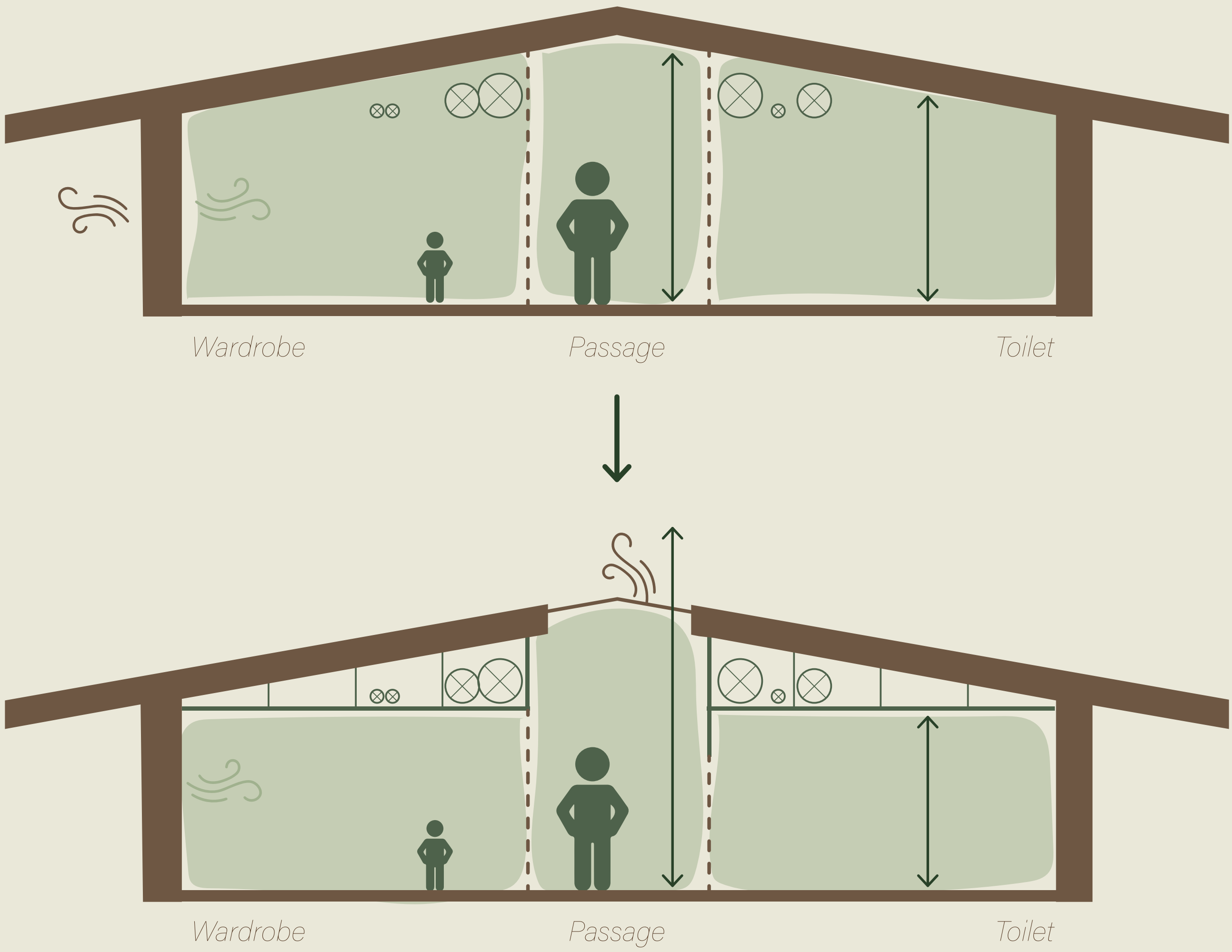




Ill. 65. Section sketch based on affordances

HUMAN SCALE

Implementing an acoustic suspended ceiling in the wardrobes makes the sound more pleasant for the users due to a lower reverberation time. The ceiling also divides the space visually because of the difference in room height. The lower room height supports room scale for the children. This architectural quality is strengthened by adding skylights in the passage to intensify the difference in room scale. Adding skylights makes it possible to achieve a better daylight condition and exploit thermal buoyancy for natural ventilation, going from single sided ventilation to cross ventilation, which is more efficient.
Mechanical ventilation ducts will be hidden above the ceiling creating a visually simple and calm design. The ceiling space can be utilized for pipes, electricity and more, which is needed to operate the building.



Ill. 66. Human scale section

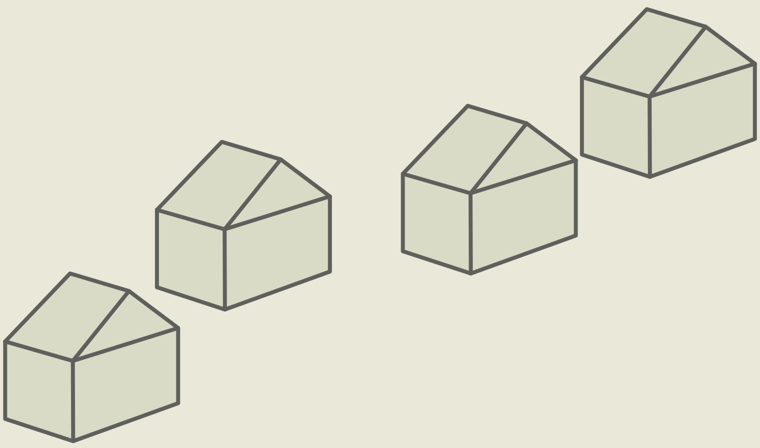
Virtual reality process

Ill. 67. Human scale 3D - Virtual reality

REVISITING THE SITE

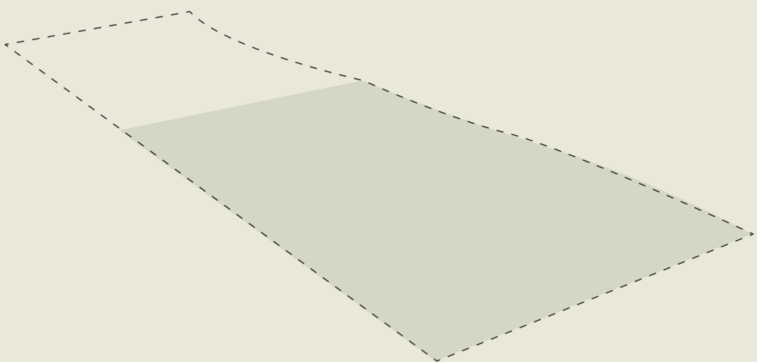
Existing trees

Preserving the existing trees to achieve the most sustainable design. The trees can be used in the design by acting as a visual barrier or fence between the kindergarten playground and the parking spot.



Considering upcoming single family houses

The upcoming single family houses will share boundary line with the kindergarten building site.



Adjusting the construction site area

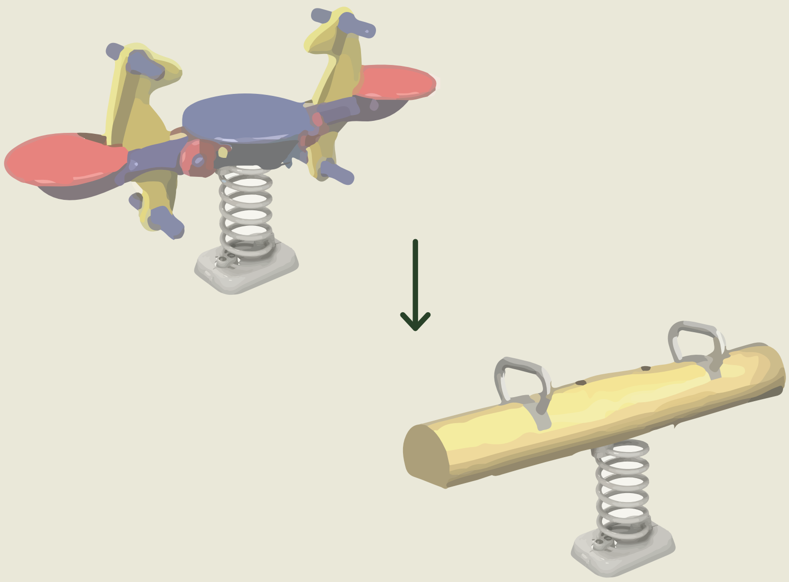
Utilizing a smaller area of the land and exploiting the existing trees as a boundary. Water accumulation will not be an issue anymore.

Ill. 68. Drone photo - revisiting the site

WORKSHOP
CONCEPTUAL SITE PLAN 4

Ill. 69. Conceptual site plan 4

PLAYGROUND DESIGN STRATEGY



Ill. 70. *Playground strategy*

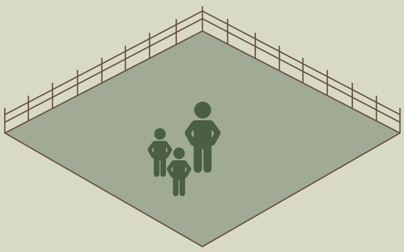
It is important to consider, how a child interprets the build environment, while designing for child lead free play. Individual objects in a playground are supposed to afford different types of play, to ensure that it will be exciting for the child day after day.
Children develop their own types of play according to their own perceptions. It is therefore important to design with an objective mind and NOT create a design which already determines how the child is supposed to play.

A great example is playground equipment such as tilts and slides which are formed as animals, pirate ships, cars, etc. These types of equipment only afford the child to do a small range of play since the interpretation for the child is decided already.

Children have great curiosity and fantasy. Using neutral and objective equipment, which no adult or designer has influenced, will allow the child to come up with new types of play, as well as keep the playground exciting for a long time.

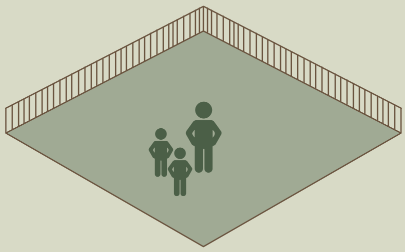
WORKSHOP FENCE

Fence types



Farmstyle fences

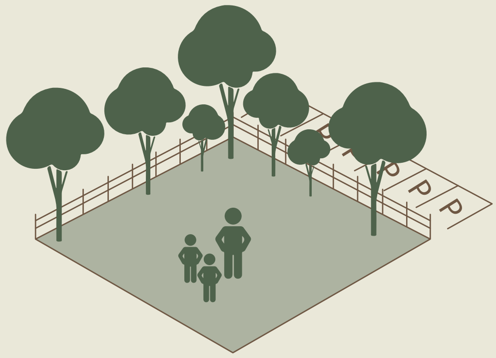
- Visually open for the children



Vertical fence

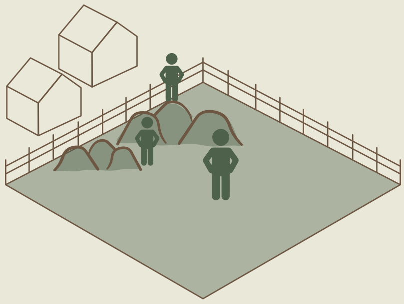
- Visually open for the children

Fence related to site



Orientation towards parking lot

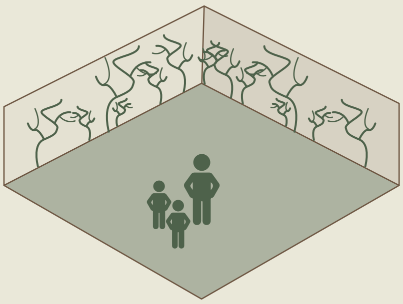
- Trees act as a visual boundary



Orientation towards upcoming houses

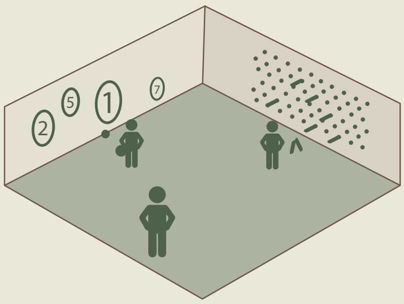
- Hills act as boundary between private and semi private

Fence details



Adding greenery to fence

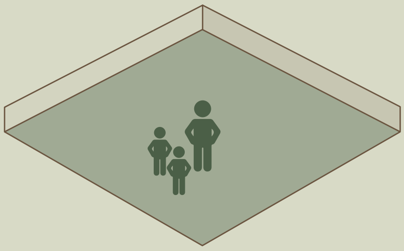
- Supports farming concept, plesent to look at and changes appearnce during the year



Interactive fence affording play

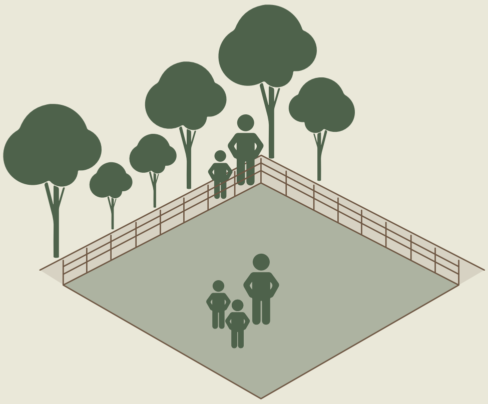
- Affords play by adding detached objects or playful activities

Ill. 71. Workshop fence



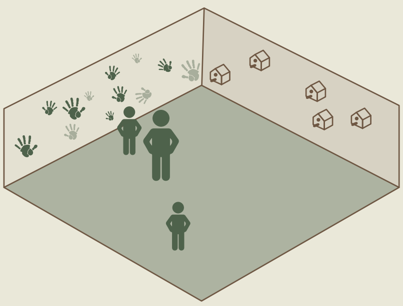
Dense fence

- Visually closed for the children



Orientation towards public path and forrest

- Path invites the local community into the kindergarten during unoccupied hours



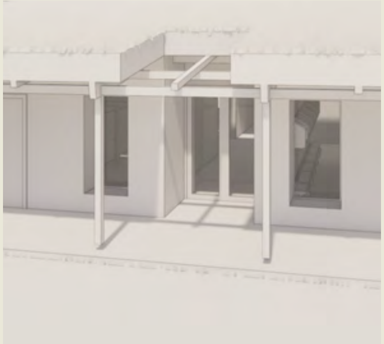
Creating ownership

- Creating ownership by adding childrens' own creations e.g. fingerprints or insect hotels.
The fingerprints show the lifespan of the building and the insect hotels provide educational value and support biodiversity.
These ideas also encourage the children to take care of the facilities.

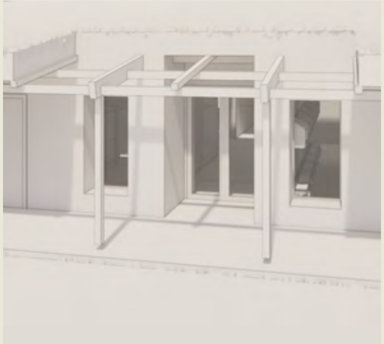
WORKSHOP ENTRANCE

Withdrawn entrance

Continuous roof

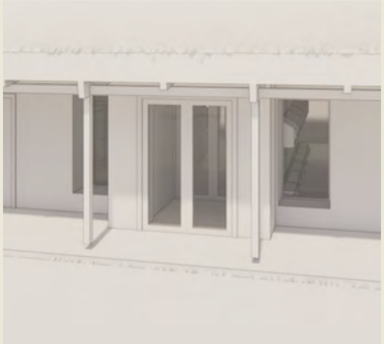


Withdrawn roof

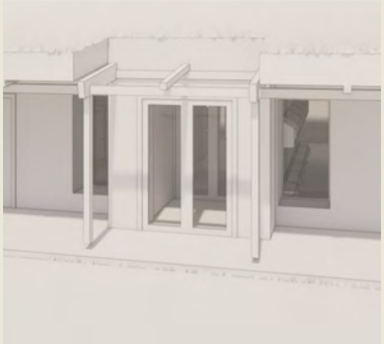


Withdrawn roof extended

Extruded entrance



Continuous roof



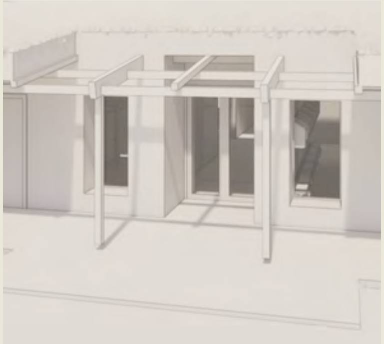
Withdrawn roof

Change in roof

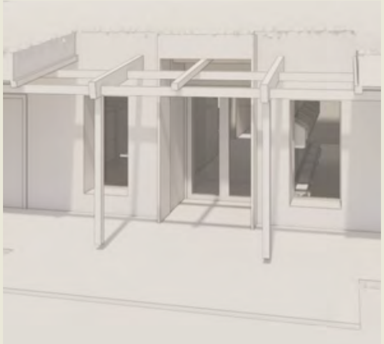
Alligned entrance

Continuous roof

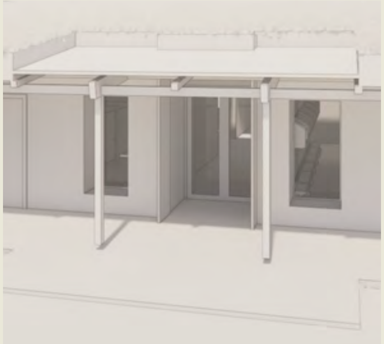
Ill. 72. Workshop entrance



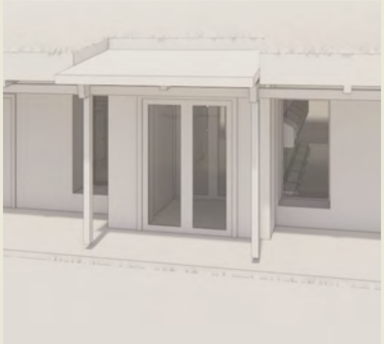
Withdrawn roof extended
Extruded plateau



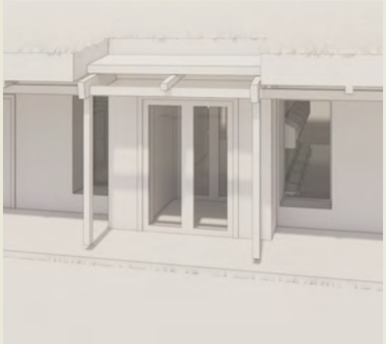
Withdrawn roof extended
Extruded plateau
Framed entrance



Change in roof
Extruded plateau
Framed entrance



Extruded changed roof



Withdrawn changed roof

Considerations:

- Awning provides shelter when entering or exiting the building
- Extruded entrance forms a "pre-entrance"-space to take off dirty shoes ect.
- Alligned facade makes entrance invisible

Conclusion: Designing a visible extruded entrance, enough to form a pre-entrance while retaining an awning, providing protection

WORKSHOP
COURTYARD DEVELOPMENT

1. Open courtyard

2. Enclosed protected space

5. Division of courtyard space

6. Division and sheltering

Ill. 73. Workshop courtyard

3. Shelter

4. Shelter and enclosed

7. Skylights of polycarbonate exploiting the daylight without any direct sun

8. Adding sliding doors
Providing shelter

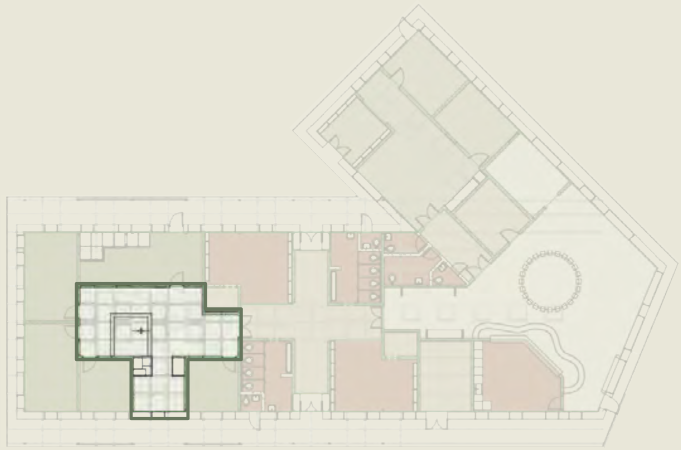
Structure emphasizing visual division of the courtyard. Provide strenght and stability for the large span in the courtyard

SECONDARY COMMON ROOM ACOUSTICS - REVERBERATION TIME

It is very important to achieve acoustic comfort in a kindergarten. The goal is to achieve 0.9 s reverbaration time or lower as stated in DGNB recomondations for a common room.

It has been decided to calculate the reverberation time in critical rooms. First investigating the secondary common room which joins all the playrooms.

This room is critical due to a goal of exposing the structure in the ceiling and therefore not adding any absorbant materials such as a suspended ceiling.



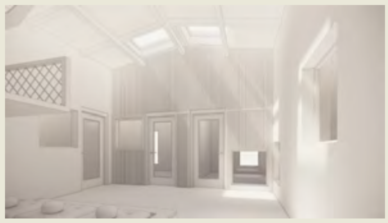
Ill. 74. Common room 2 highlight

No acoustic strategies ✕

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0,8 s	0,6 s	*1,1 s*	*1,6 s*	*1,4 s*	*1,3 s*

Absorbant wall board

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0,5 s	0,3 s	0,3 s	0,5 s	0,6 s	0,8 s

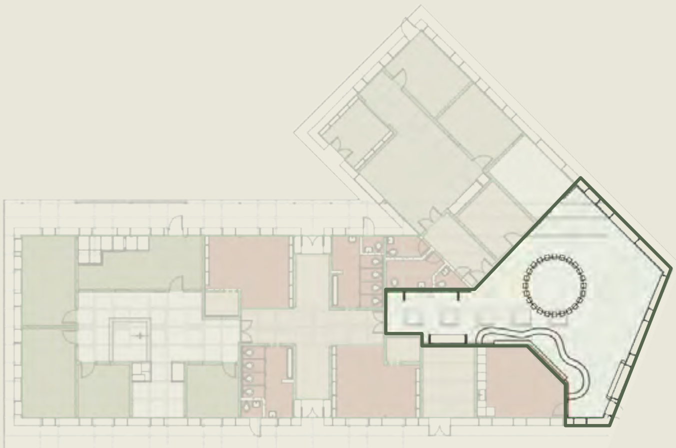


Ill. 75. Virtual reality visualization

COMMON ROOM ACOUSTICS - REVERBERATION TIME

The common room is at first analyzed without any acoustic strategies. Followed by adding an acoustic suspended ceiling.

Since the suspended ceiling is not enough to achieve the wanted reverberation time the walls will be taken into consideration.
Dividing walls will be added to achieve a bigger wall surface to aborb sound for acoustic comfort. They will also act as an architectural benefit to accomplish visual comfort in terms of visually splitting the area for the children to be dividided into smaller groups while eating, or during guided play



Ill. 76. Common room 1 highlight

No acoustic strategies ✗

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0,8 s	0,7 s	1,1 s	1,7 s	1,4 s	1,3 s

Suspended ceiling ✗

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0,8 s	0,3 s	0,4 s	0,5 s	0,8 s	1,2 s

Suspended ceiling and absorbant wall dividers

125 Hz	250 Hz	500 Hz	1000 Hz	2000 Hz	4000 Hz
0,6 s	0,2 s	0,2 s	0,4 s	0,6 s	0,9 s

Ill. 77. Virtual reality visualization

COMMON ROOM WINDOW TO WALL RATIO

Monthly average calculation

Month average calculations have been used as a tool to investigate which percentage of windows would be possible to implement in the design, without getting fluctuating and hot temperatures in the hottest month, August. Window percentage of 25, 50, and 75 has been calculated with the most critical scenario where all users of the building occupy the room.

The bigger the windows are the more fluctuating temperatures due to greater heatloss and solar gains. Comparing this to the daylight the daylight factor will get worse the smaller the windows are. This will be investigated further by doing a Bsim simulation and daylight calculation to analyze the thermal comfort as well as a daylight factor analysis to determine the visual comfort.

Daylight factor will be less than 2% on average

25% window ✕

Month average temperature: 21.2 °C
Temperature variation: 4.4 °C
Max temperature: 23,2 °C

Will be investigated further

50% window

Month average temperature: 21.9 °C
Temperature variation: 5.0 °C
Max temperature: 24,4 °C

Temperature fluctuate more than 5 °c

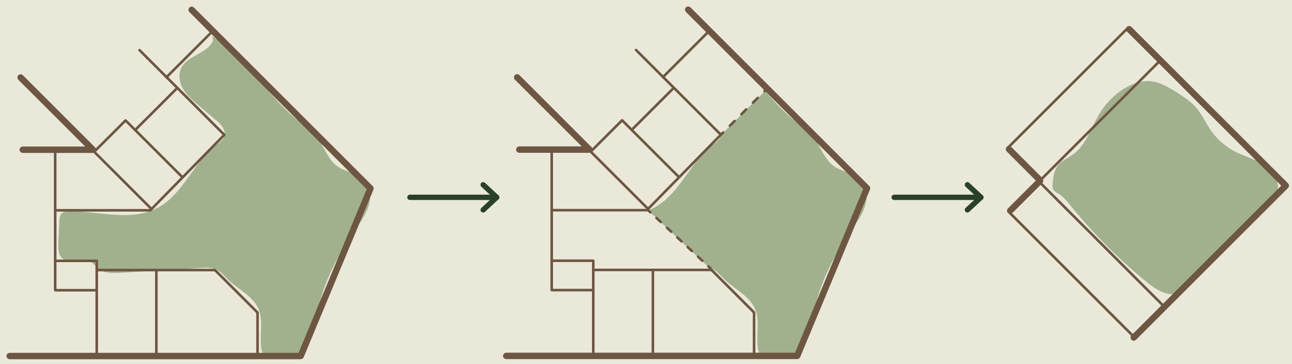
75% window ✕

Month average temperature: 22.6 °C
Temperature variation: 5.5 °C
Max temperature: 25,3 °C

COMMON ROOM COMFORT SIMULATION

Simplification

The data input for the software has to have the same level of detail as the level of detail for the 3D model. The 3D geometry is therefore simplified to comply with the data input. If the level of detail between the model and the input does not comply with each other the simulation will be different from reality.



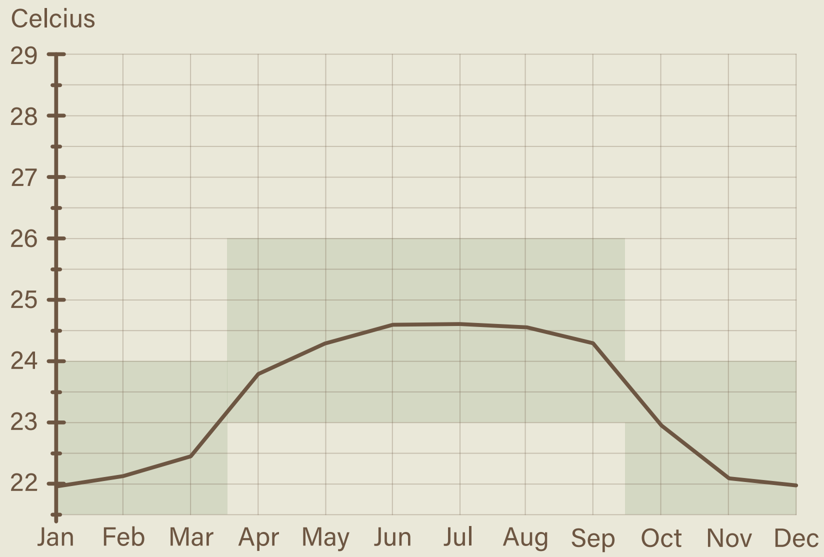
Ill. 79. Bsim simplification

Monthly average simulation

Data input for the Bsim simulation has a higher level of detail than the regular month average calculation. Leading to a slightly different result between the calculation and simulation.

Ill. 78. highlights the monthly average temperatures from the Bsim simulation. The temperatures comply with the recomended temperatures for winter (20 - 24 °C) and summer (23 - 26 °C) on average.

Month average temperature does not highlight how the temperatures tend to fluctuacte according to outdoor temperature and solar radiation. Therefore it is important to consider the 24h temperatures for critical days (winter and summer solstice).

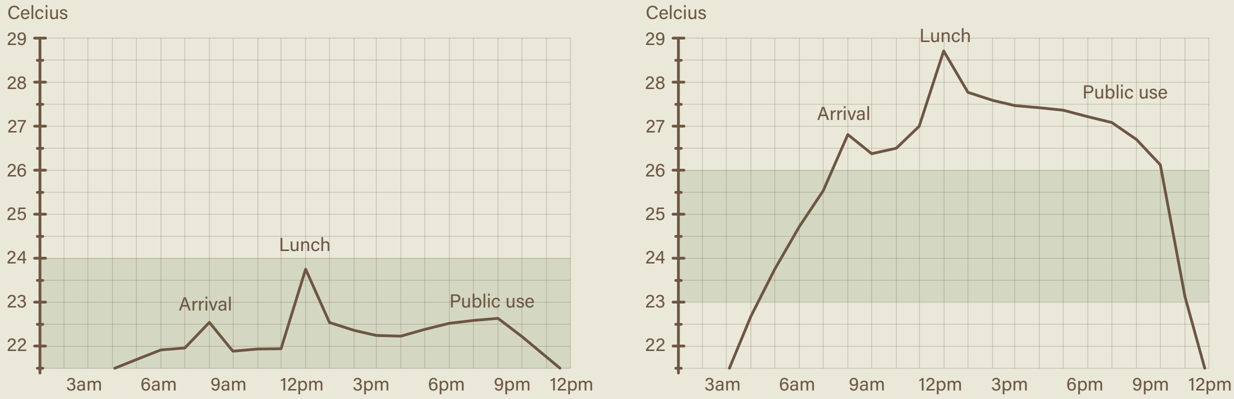


Ill. 78. Bsim simulation

Development of Bsim simulation

Step 1: First initial simulation

Winter solstice (20-24 °C) | Summer solstice (23-26 °C)



Ill. 80. Bsim simulation

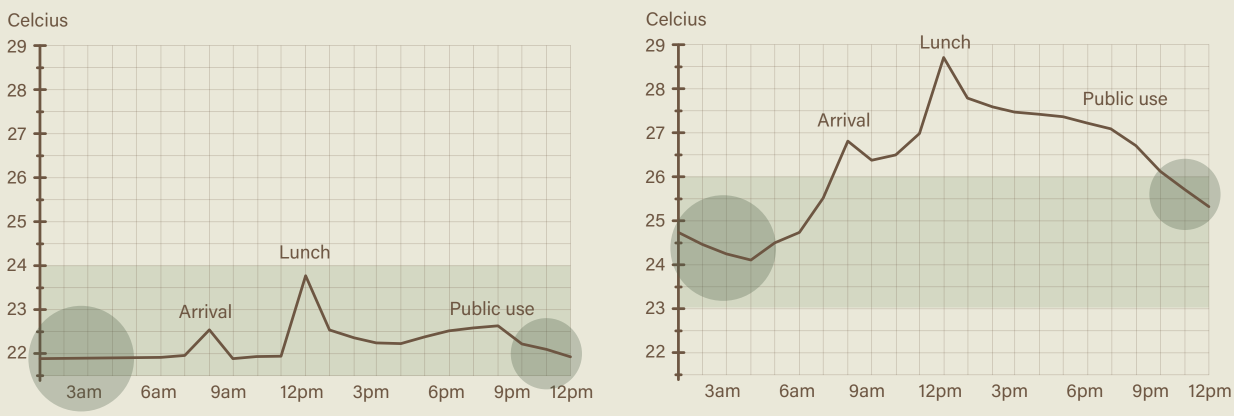
Hours above 26 °C: **1696**/100
Hours above 27 °C: **952**/25
Hours below 20 °C: **1162**/0

Step 2: Implementing minimum ventilation at night and in the weekends. VAV-turns ventilation on before the first person arrive

Hours above 26 °C: **1126**/100
Hours above 27 °C: **439**/25
Hours below 20 °C: **1128**/0

Step 3: Implementing minimum heating at night and in the weekends.

Winter solstice (20-24 °C) | Summer solstice (23-26 °C)



Ill. 81. Bsim simulation

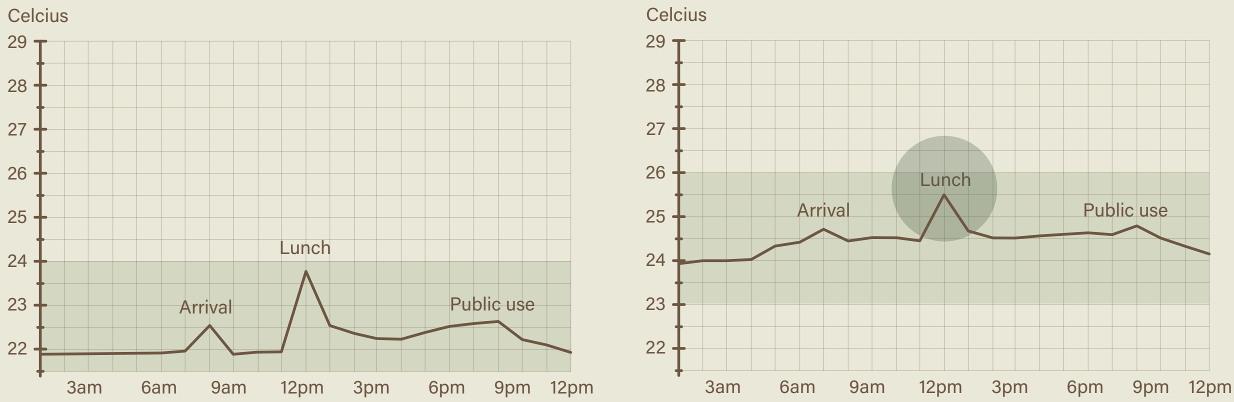
Hours above 26 °C: **1127**/100
Hours above 27 °C: **439**/25
Hours below 20 °C: **0**/0

Step 4: Implementing a ventilation unit with a passive cooling coil. Utilizing the cold air to cool down water which cools down the inlet air within the ventilation unit.

Hours above 26 °C: **1065**/100
Hours above 27 °C: **334**/25
Hours below 20 °C: **0**/0

Step 5: Implementing natural ventilation in summer months when the temperature reaches 26 °C

Winter solstice (20-24 °C) | Summer solstice (23-26 °C)



Ill. 82. Bsim simulation

Hours above 26 °C: **86**/100
Hours above 27 °C: **18**/25
Hours below 20 °C: **0**/0

86 hours above 26 °C and 18 hours above 27 °C with an average between the recomended temperatures. It is important to not only use the average temperature but also understand how much the temperatures within critical days fluctuate. A suitable average value can have over or under temperatures. Critical days are summer and winter solstice analyzing the day as regular workdays with occupation. Each day is similar but differs according to outdoor temperature and solar radiation. Furthermore, the temperature adjusts according to how many people occupy the room, therefore the temperatures are higher during lunchtime.

The natural ventilation is set to work according to DGNB recommendations when the temperature during Summer and Winter is rising to its max (26 and 24 °C) and when the CO_2 concentration in the room reaches 900 ppm. This is how the sensors in the room are planned to tell the users when to open a window. If the user is not satisfied with the temperature it is possible to open the window resulting in a lower temperature. This might be of benefit during lunch time. To prevent over heating it will be possible to change the set point or the sensor to 25 °C instead of 26 °C.

COMMON ROOM
WINDOWS AND DAYLIGHT

No window sill

Making window niches by moving glazing

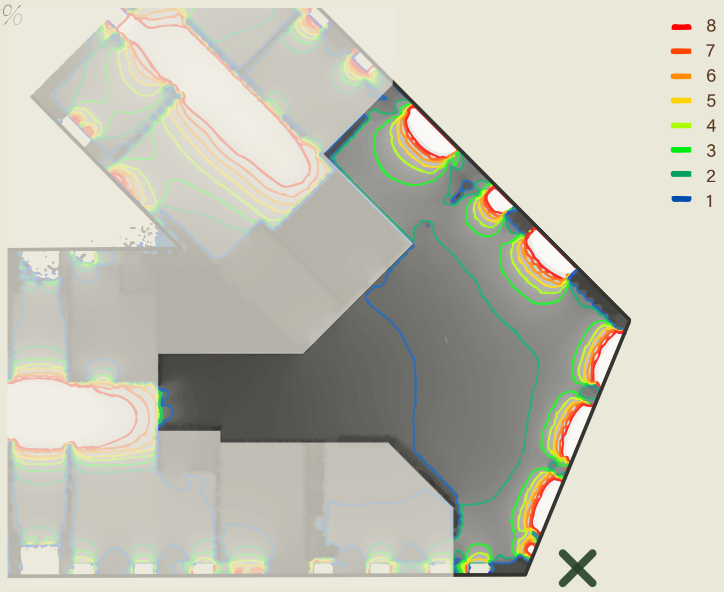
Adjusting window sizes according to function

Affordance: Invite children to utilize windows

Ill. 83. Window and daylight principles

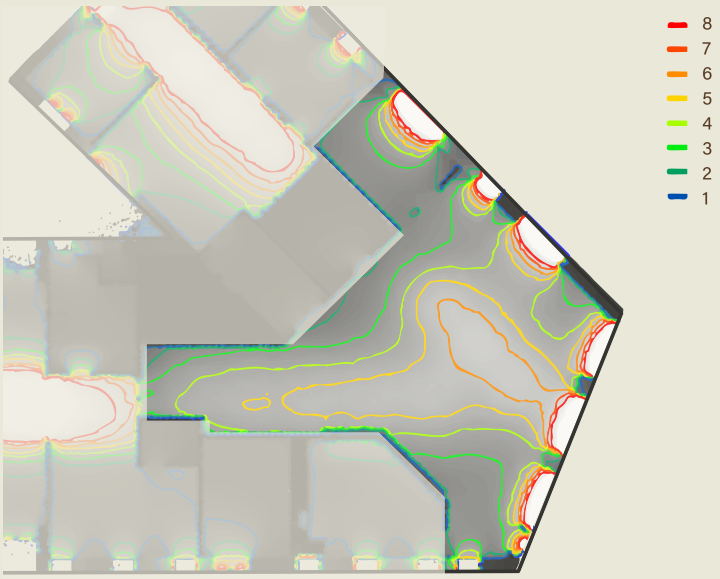
Initial daylight analysis

Daylight factor below 2%



Adding skylight cones

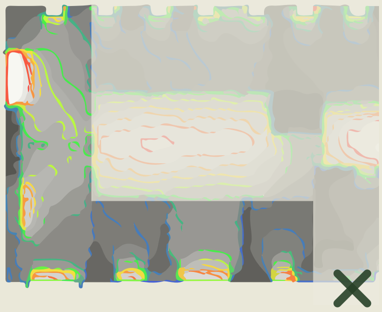
Daylight factor above 3%



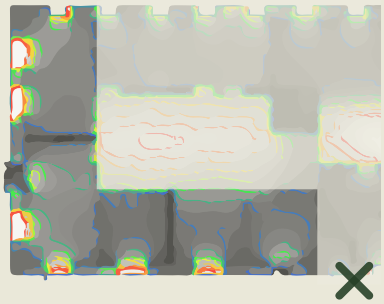
Ill. 84. Daylight optimization

WORKSHOP
WINDOWS AND FACADE

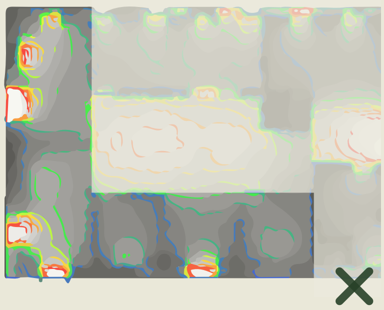
Facade option 1



Facade option 2



Facade option 3



Ill. 85. Facade workshop

Facade option 4

Facade option 5 - Fits to the grid system and provides an average daylight factor above 2.5%

Facade option 6

Ill. 86. Facade workshop

LITERATURE

Books, articles, journals, ect.

Bies, Hansen (1988) *Engineering noise control.* [online via internal VLE], Aalborg University. Last accessed: 17.05.2021

Dansk Standard: (2001) *DS/CEN/CR 1752 Ventilation i bygninger - projekteringskriterier for indeklimaet.* page 12-16, 107. 1. edition. Dansk Standard

Green Building Council Denmark (2017) *DGNB system Denmark* (1. edition) Copenhagen

Internet sources

EcoCocon (2021) *Et modulsystem designet af naturen.* Last accessed: 13.05.2021
https://ecococon.eu/dk/element

EcoCocon (2021) *For architects.* Last accessed: 12.05.2021
https://ecococon.eu/assets/downloads/ecococon-brochure.pdf

Emdén, Teodor Javanaud (2021) *Skalgubbar.* Last accessed: 17.05.2021
https://skalgubbar.se/

Heiselberg (2019) Zero energy buildings: *Modeling of natural ventilation and hybrid ventilation 1/2*, Lecture 11 MSc01-arch 2019 [online via internal VLE], Aalborg University. Last accessed: 17.05.2021

Larsen, Tine Steen (2018) Husbyggeri 2: *Hygrotermisk bygningsfysik*, Lecture 1 BSc05-arch 2018 [online via internal VLE], Aalborg University. Last accessed: 17.05.2021

ILLUSTRATIONS

Illustrations which are not mentioned in this list are owned or created by
Ida-Katrine Arend Grün Hansen

Ill.25 - Conceptual site plan 2 - building inspiration
Location: https://pin.it/27LwQAs
Last accessed: 18.05.2021

Ill. 40 - Inspiration pictures from Pinterest board
Location: https://pin.it/27LwQAs
Last accessed: 18.05.2021

PART 03

Master Thesis 2021

Aalborg University

Overby Bakke Kindergarten

57°05'10.3"N 10°05'09.7"E

Ida-Katrine Arend Grün Hansen

TITLE

Aalborg University
Master in Architecture

Department
Architecture, Design and Media Technology

Semester MSc04
Master Thesis - Overby Bakke Kindergarten
01.02.2021 - 15.06.2021

Group 16

Submission 27.05.2021

Supervisor
Tenna Doktor Olsen Tvedebrink

Part
3/3 - Presentation phase

Pages
75 + 13

Appendixes
6

Ida-Katrine Arend Grün Hansen

READER'S GUIDE

This report is structured by the integrated design process, divided into three parts: **01** Problem- and analysis, **02** sketching- and synthesis, and **03** presentation. This is part **03** representing the presentation phase of the project.

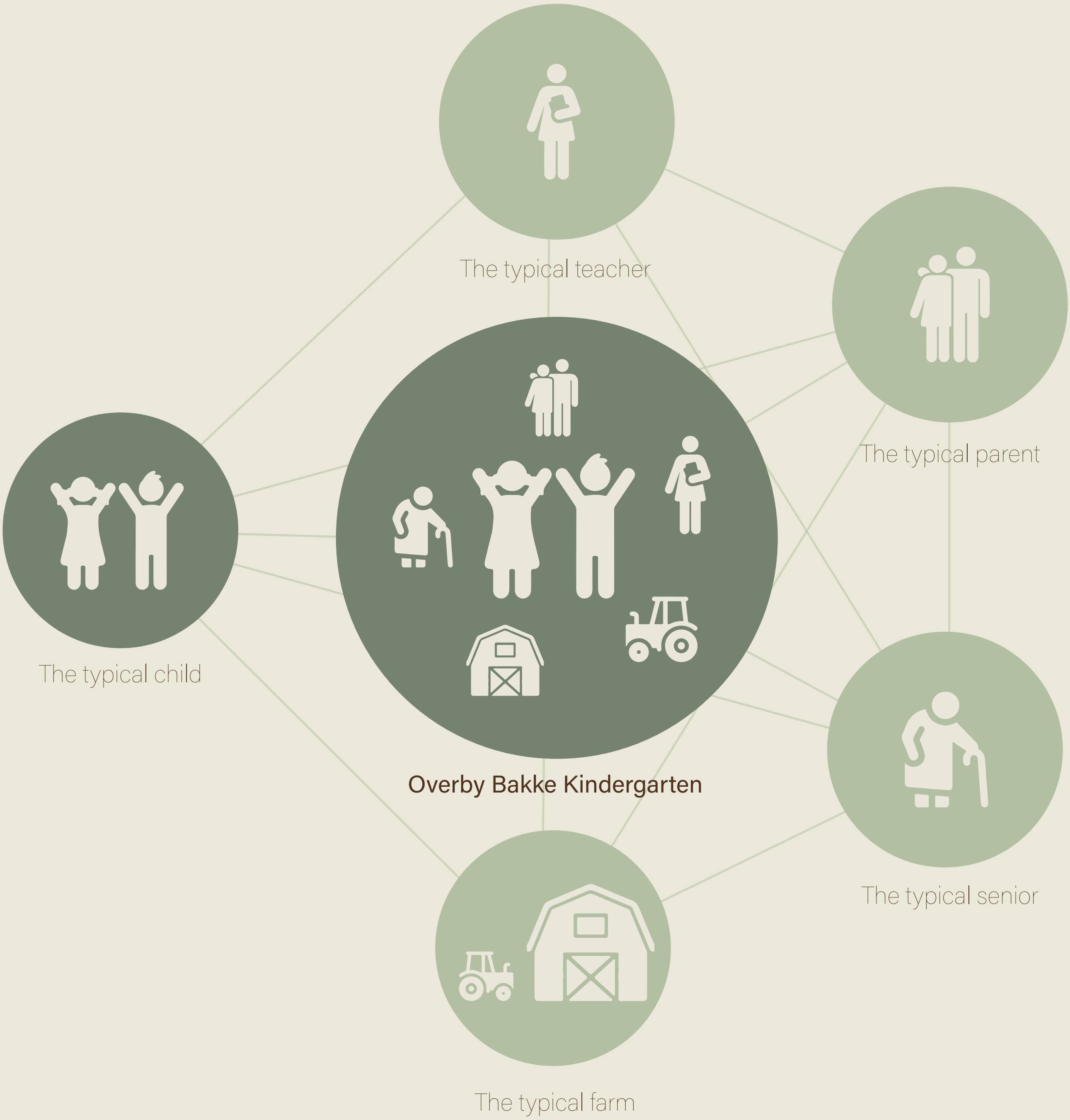
This phase presents the design proposal of Overby Bakke Kindergarten through plans, sections, renders and narratives.

When reading part 03 this symbol will occur. The symbol indicates that the sheet is an A3 page which can be unfolded. Please do so, in order to read the report intentionally.

CONTENT

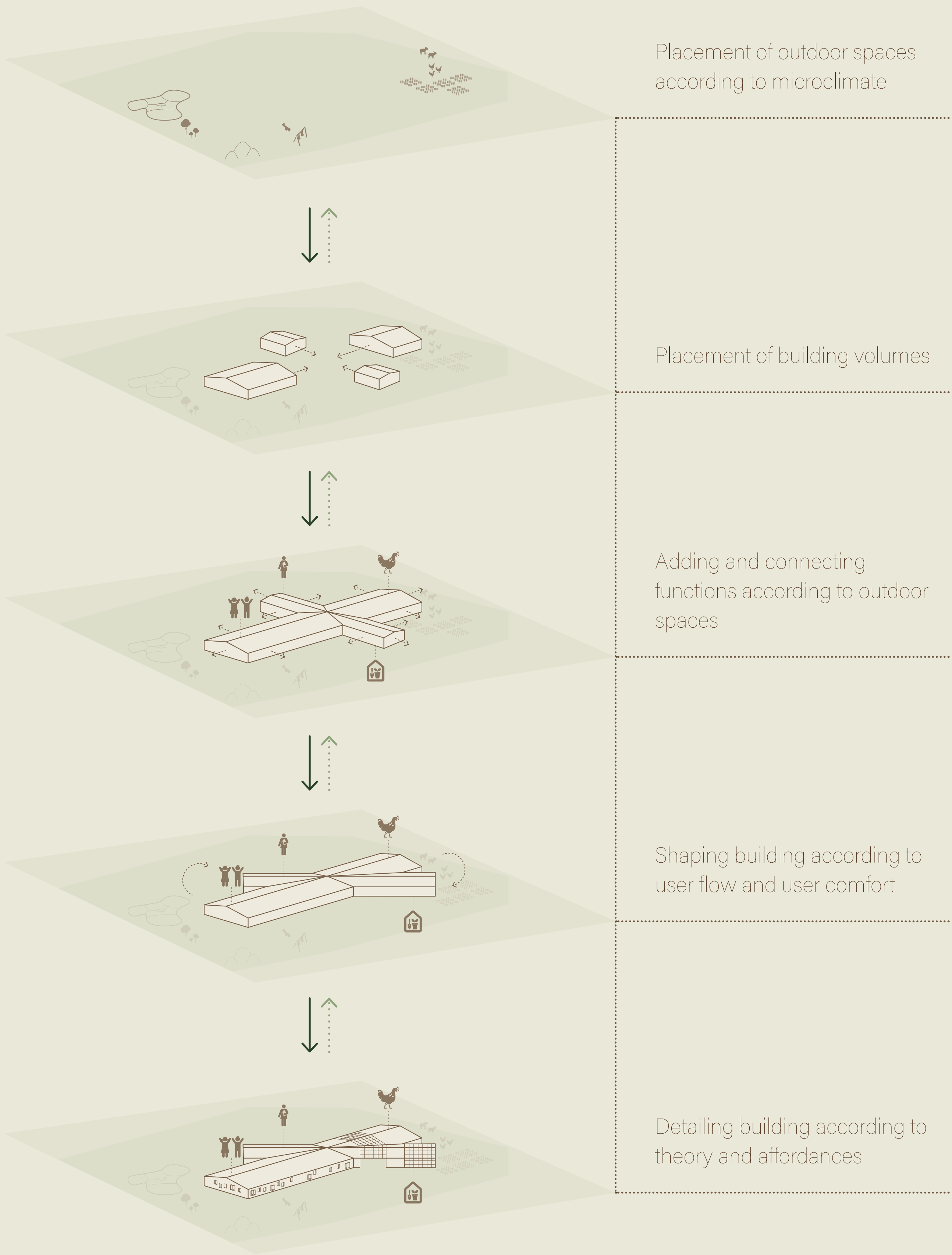
CONCEPT

The concept is based on a holistic approach unifying the everyday life in a kindergarten with the local community through shared farming facilities, exploiting the existing atmosphere and providing intergenerational development.



Ill. 1. Concept

CONCEPT DEVELOPMENT



Placement of outdoor spaces according to microclimate

Placement of building volumes

Adding and connecting functions according to outdoor spaces

Shaping building according to user flow and user comfort

Detailing building according to theory and affordances

Ill. 2. Concept development in steps

Ill. 3. Situation map 1 : 75.000

OVERBY BAKKE

Ill. 4. 1 : 5.000 Overby Bakke

MASTER PLAN 1 : 500

Ill. 5. Master plan 1 : 500

Approaching the site, the first thing you realize is children laughing, before being met with a green field always occupied by different activities. By its slender and cohesive volume, Overby Bakke Kindergarten lays peacefully on the open field at the far north of Overby Bakke. Children are playing throughout the entire site during all seasons. E.g., when they plant or harvest crops in summer, take part in water play during rain in fall, sled down the hills during snow in winter, or build insect hotels in spring.

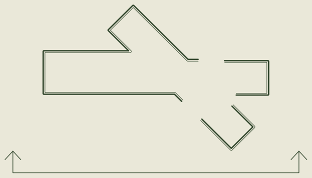
Whether you are visiting the kindergarten to pick up your child, to use the shared facilities or to take a night out in the shelters in the weekend, you will always feel a sense of life in the building. If the building is not used as a kindergarten, the seniors of Overby Bakke might use the common room, courtyard, or greenhouse to do a knitting workshop, if a local has not been renting the space for a gathering first.

The building unifies children, Overby Bakke's local community, sustainability, and farming, meaning without every little aspect, the atmosphere in Overby Bakke kindergarten would not exist.

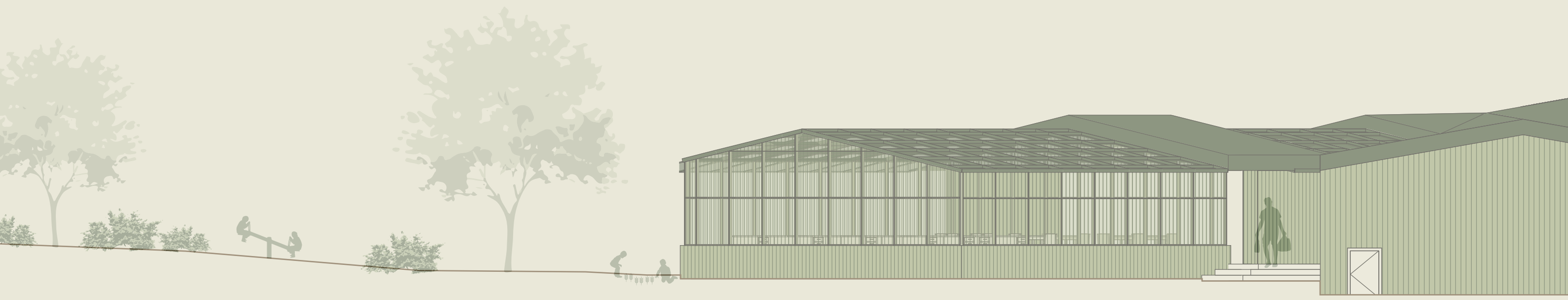
ELEVATIONS

South elevation 1 : 200

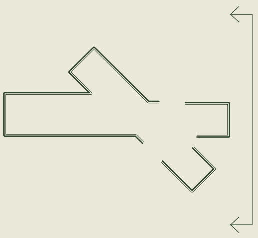
Ill. 6. South elevation 1 : 200

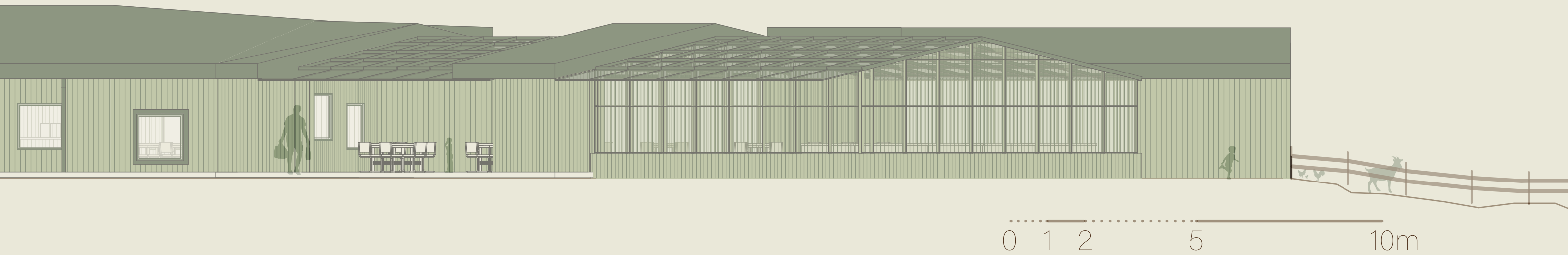


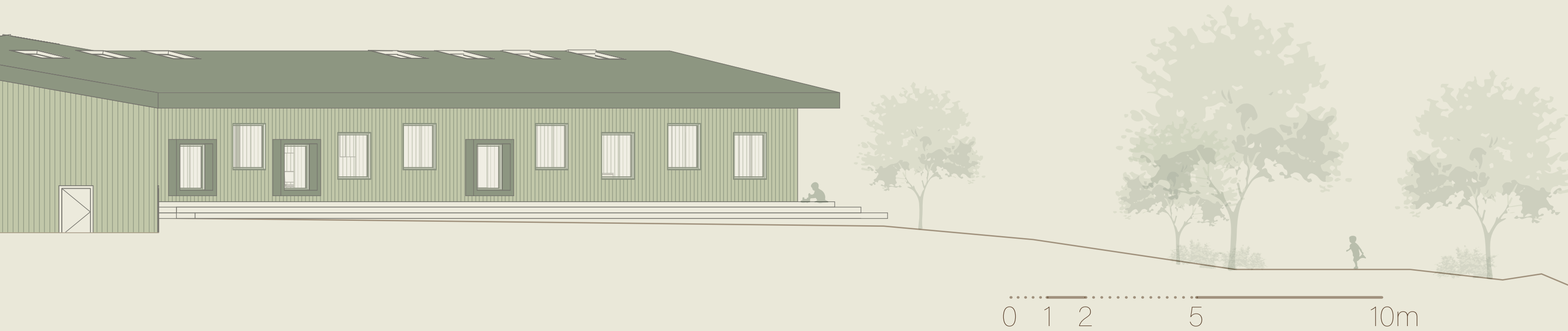
East elevation 1 : 200



Ill. 7. East elevation 1 : 200

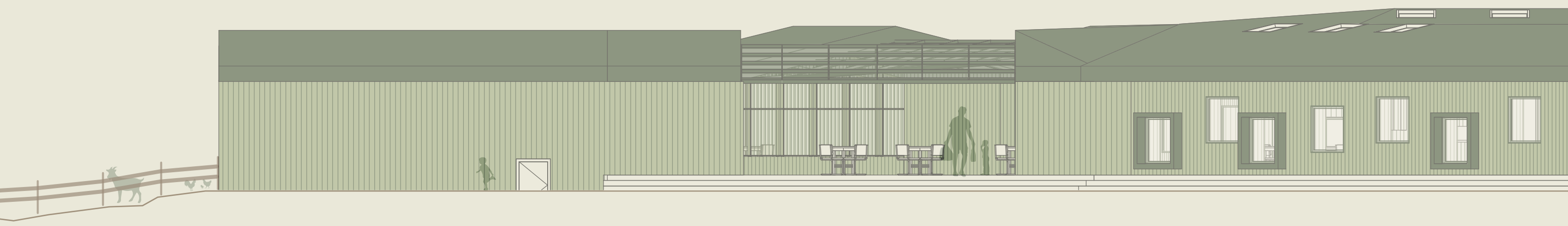



0 1 2 5 10m

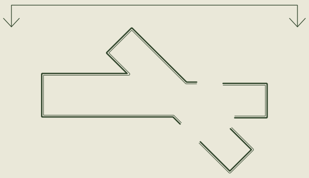

0 1 2 5 10m

ELEVATIONS

North elevation 1 : 200

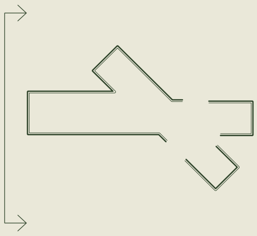


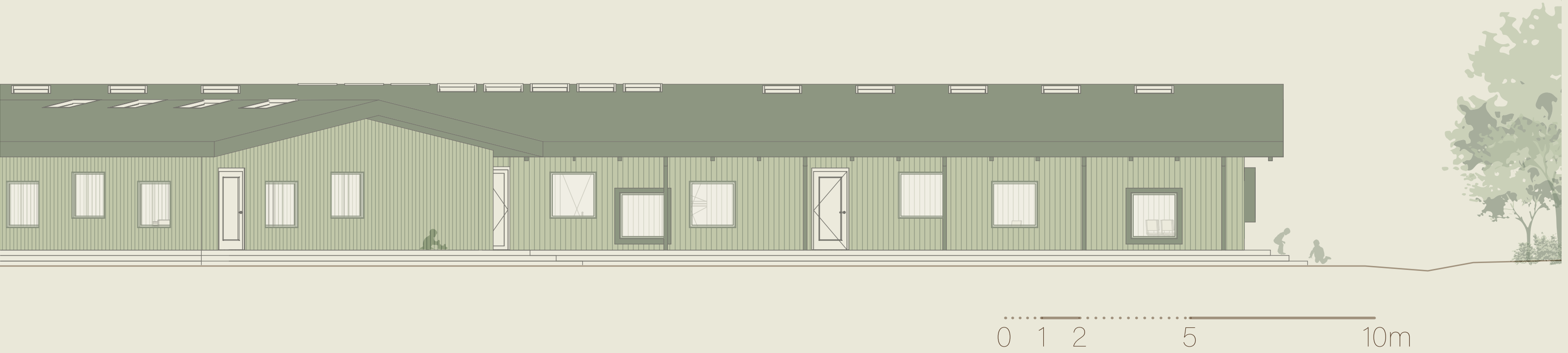
Ill. 8. *North elevation 1 : 200*

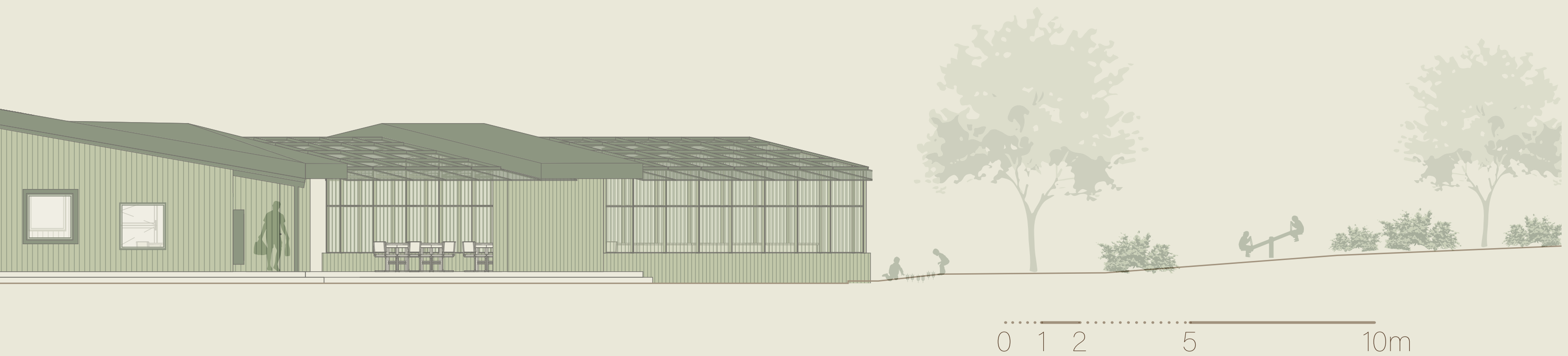


West elevation 1 : 200

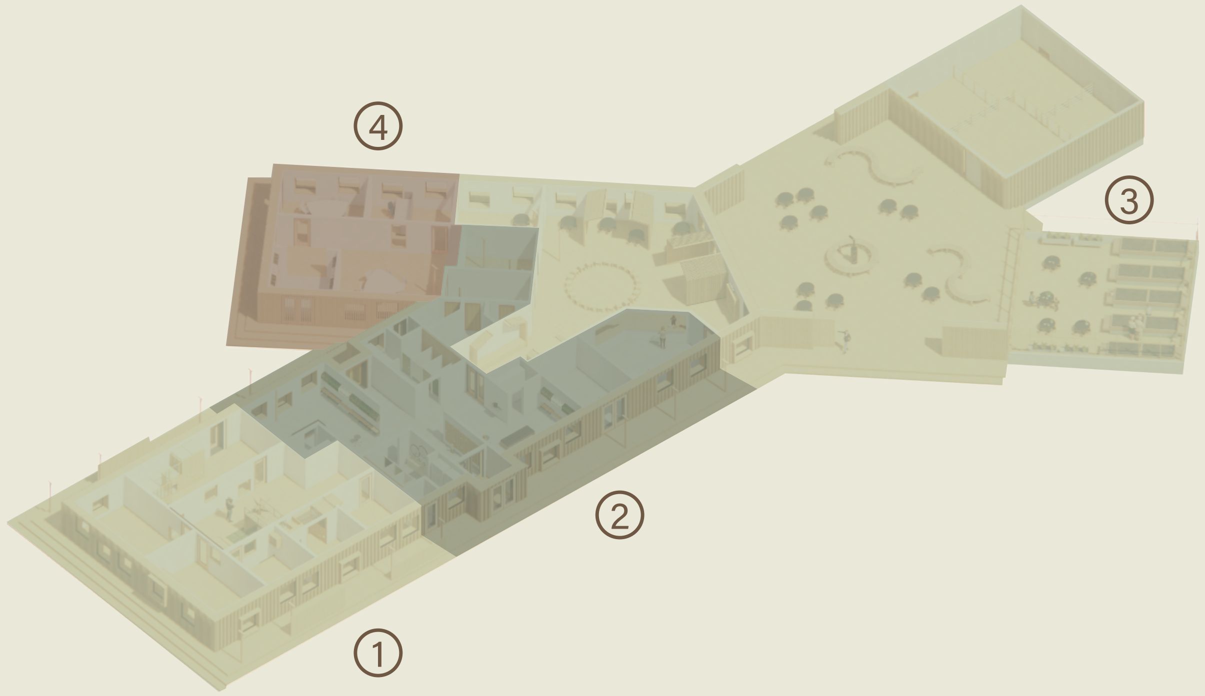
Ill. 9. *West elevation 1 : 200*







PLAN



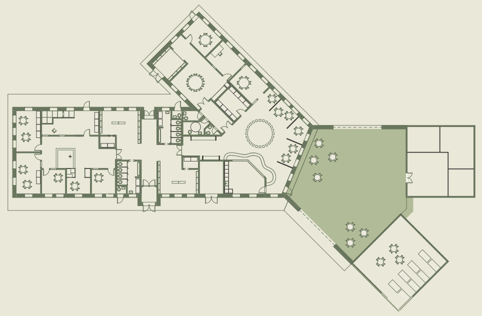
Ill. 10. Area distribution

1	Play zone
2	Functional zone
3	Shared zone
4	Staff zone

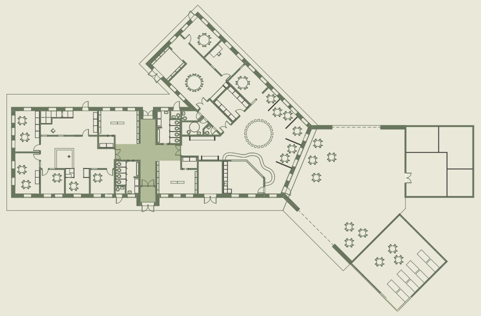
PLAN 1 : 200

1	Playroom	23 / 14 m²
2	Common room	157 / 66 m²
3	Sleeping	33 m²
4	Wardrobe	28 m²
5	Toilet	19 m²
6	Staff area	103 m²
7	Entrance / passage	6 / 45 m²
8	Storage	26 m²
9	Greenhouse	100 m²
10	Workshop	38 m²
11	Animal barn	104 m²
12	Courtyard	220 m²
13	Technical	19 m²
14	Kitchen	28 m²

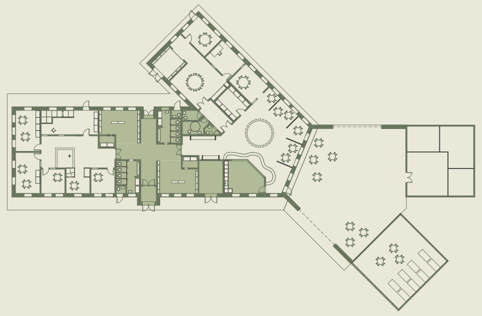
Total main building:	708 m²
Total build:	912 m²
Total:	1132 m²



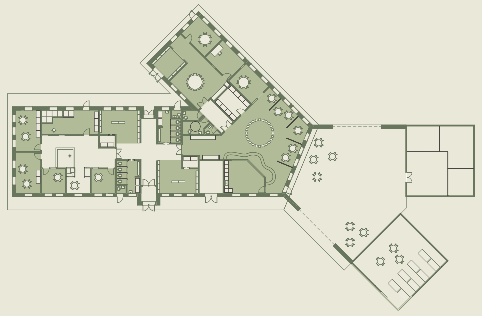
Courtyard
Main gathering and meeting place of the building



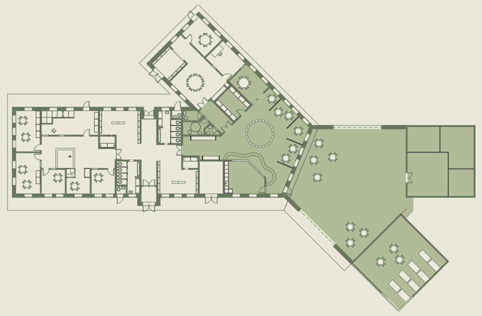
Passage
Main passage connecting functions in the building, subconsciously creating a secondary meeting place.



Functional flooring
Easy cleaning flooring in functional area of wardrobe, toilets and passage.



Suspended ceiling
To achieve acoustic comfort as well as visual comfort in terms of a simple and calm design. (Floor to ceiling: 2.800 mm)

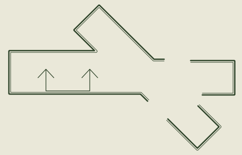


Local community
Security boundary between semi-public rental rooms and private kindergarten rooms

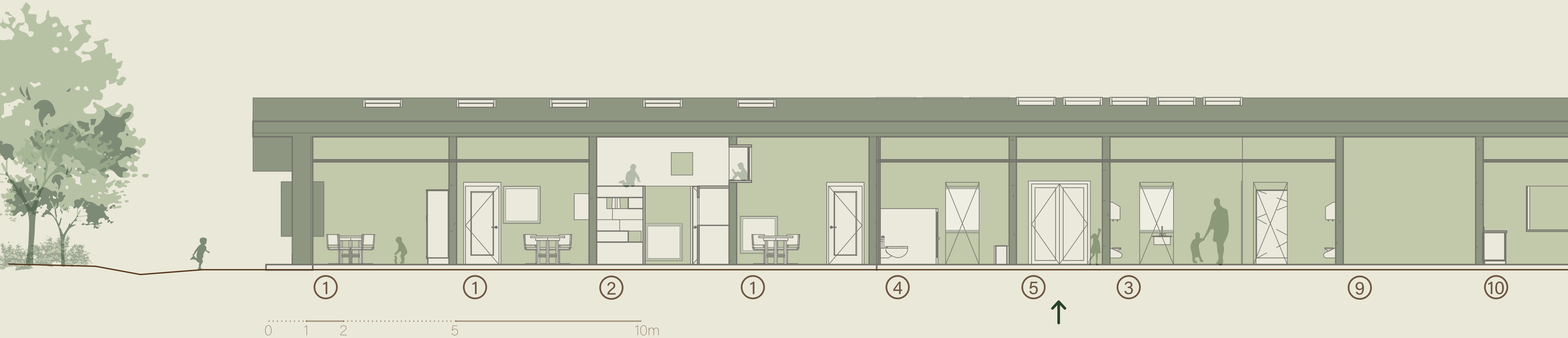
Ill. 12. Plan highlight diagrams

SECTIONS

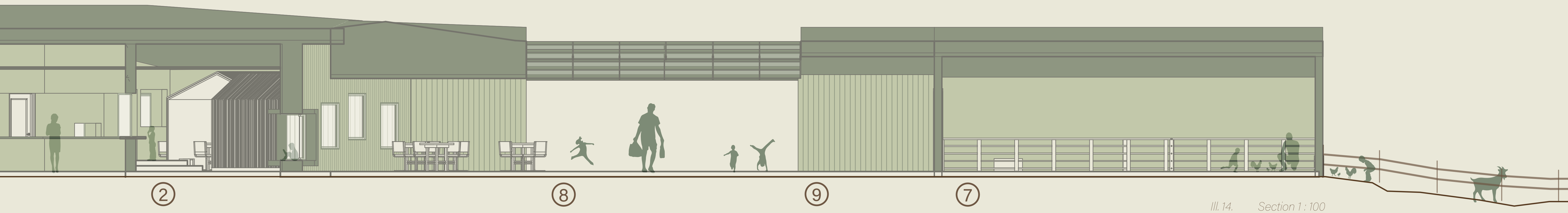
Ill. 13. 3D section play tower



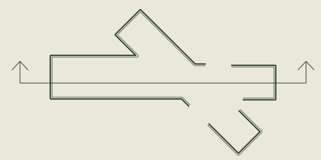
SECTION 1 : 100



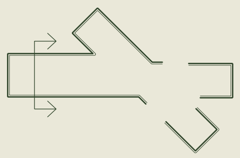
1	Playroom	23 / 14 m²
2	Common room	157 / 66 m²
3	Wardrobe	28 m²
4	Toilet	19 m²
5	Entrance / passage	6 / 45 m²
6	Workshop	38 m²
7	Animal barn	104 m²
8	Courtyard	220 m²
9	Technical	19 m²
10	Kitchen	28 m²



Ill. 14.   Section 1 : 100



Ill. 15. 3D section play area



MATERIALS

Interior

Ill. 16.

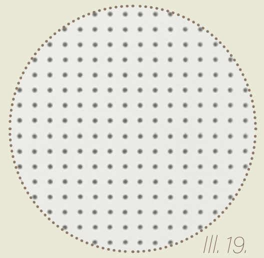
Recycled gym floor
from an old gym in Vester Hassing

Ill. 17.

Concrete
easy floor cleaning in wardrobes

Ill. 18.

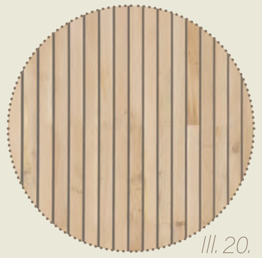
Plywood
details highlighting windows and play areas



Ill. 19.

Clay plaster
As interior walls and acoustic ceiling boards

Exterior



Ill. 20.

Thermal oak cladding
allowing seams to avoid waste material. Treated without chemicals

Ill. 21.

Concrete
foundation

Ill. 22.

Polycarbonat
Provides solar UV prote-ction to greenhouse and courtyard, not compro-mising daylight

Ill. 23.

Pea stone
fall absorbant base ground

Green roof

Ill. 24.

White clover
Maintain ecosystem for soil

Ill. 25.

Cone flower and daisy
Maintain ecosystem for bugs

Ill. 26.

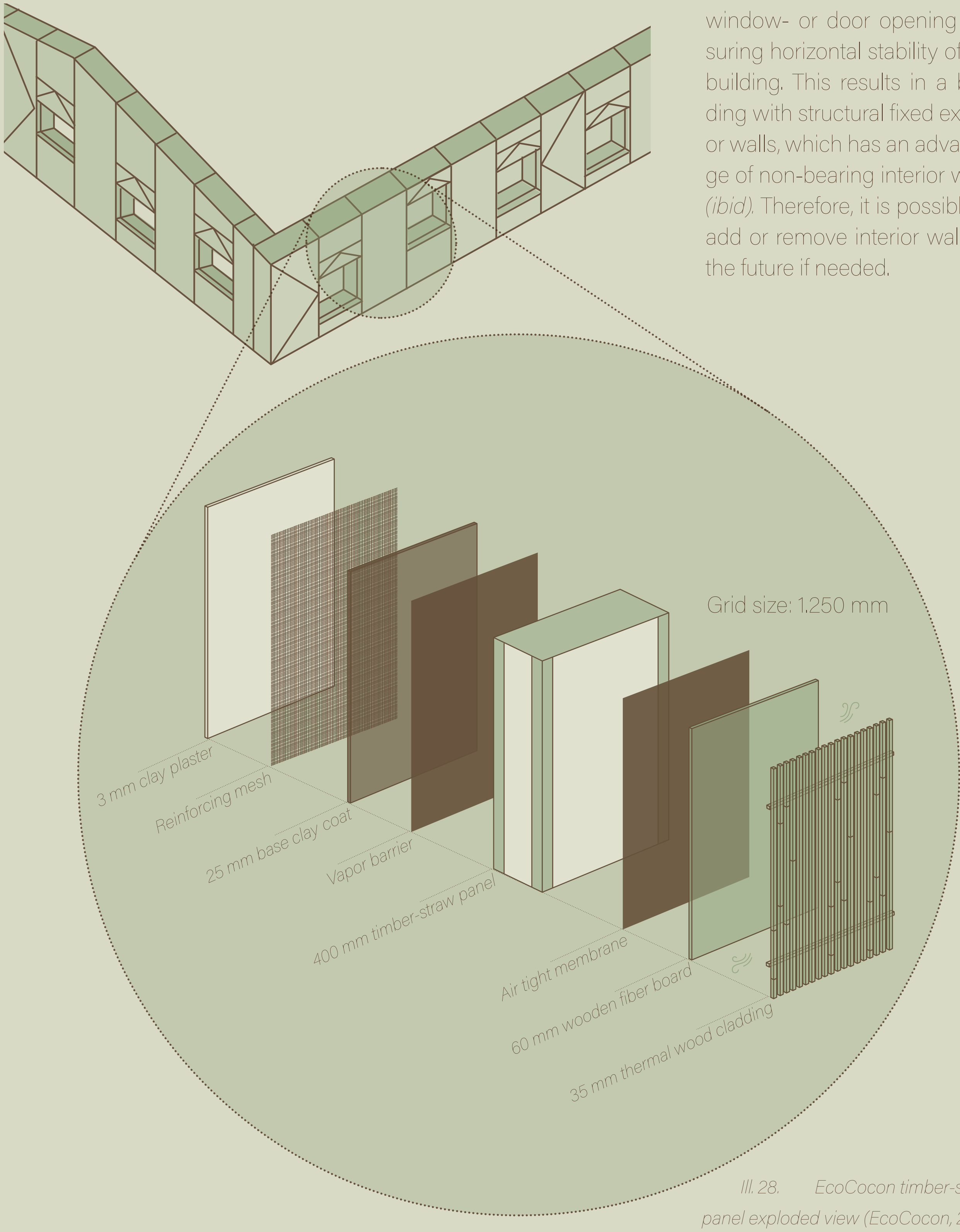
Moss carpet
Water absorbant base

Ill. 27.

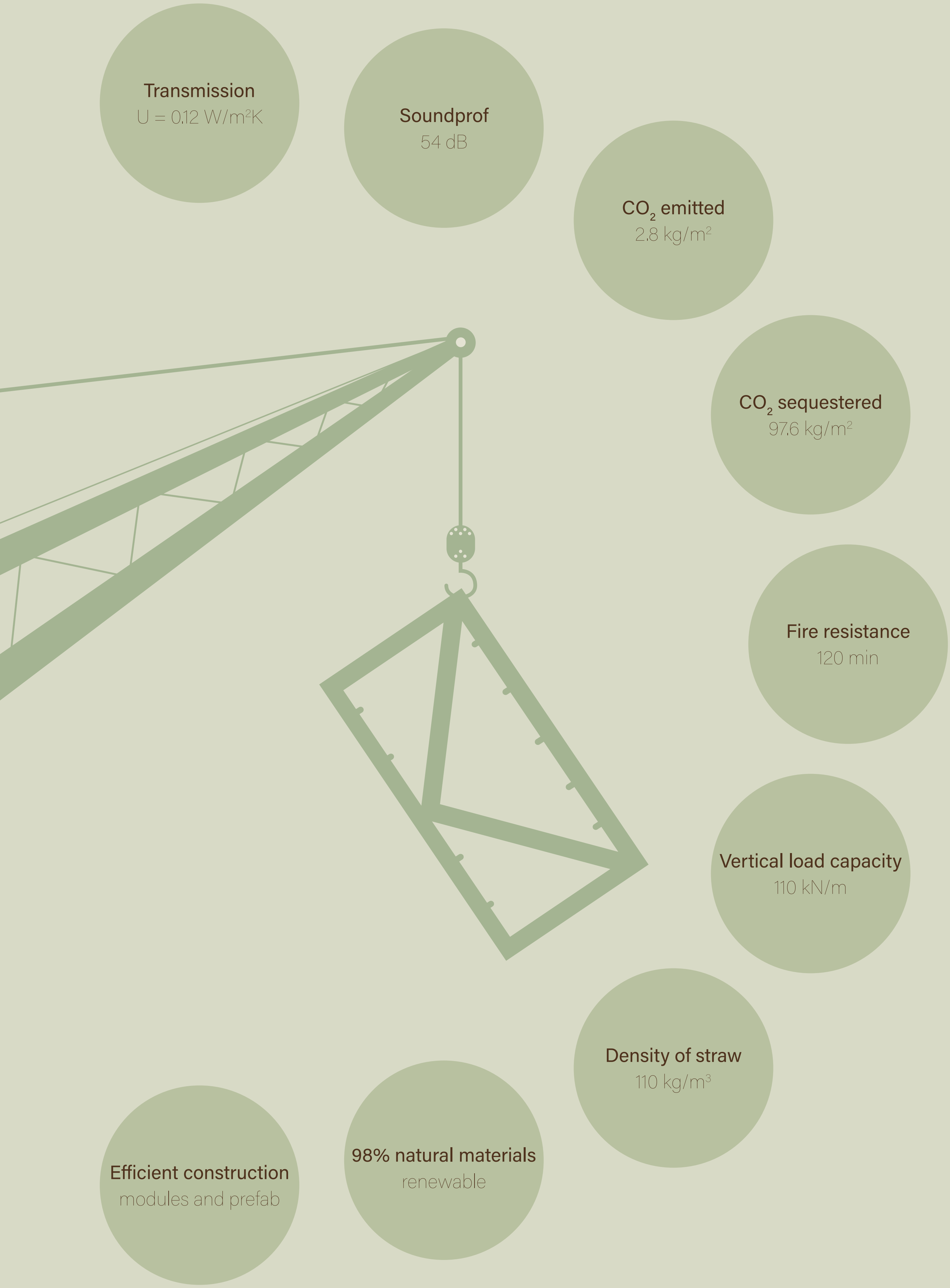
Texas sedge grass
Water draining base

ECOCOCON TIMBER-STRAW PANEL

EcoCocon straw panels are designed especially for passive house standards in cold climates *(EcoCocon, 2021)*. The module is customizable which makes it possible to fit the buildings grid system of 1.250 m. The panel is constructed out of FSC-classified wood with a double load capacity achieving a sufficient vertical load bearing structure *(ibid)*. Bracings will be added to elements without window- or door opening ensuring horizontal stability of the building. This results in a building with structural fixed exterior walls, which has an advantage of non-bearing interior walls *(ibid)*. Therefore, it is possible to add or remove interior walls in the future if needed.

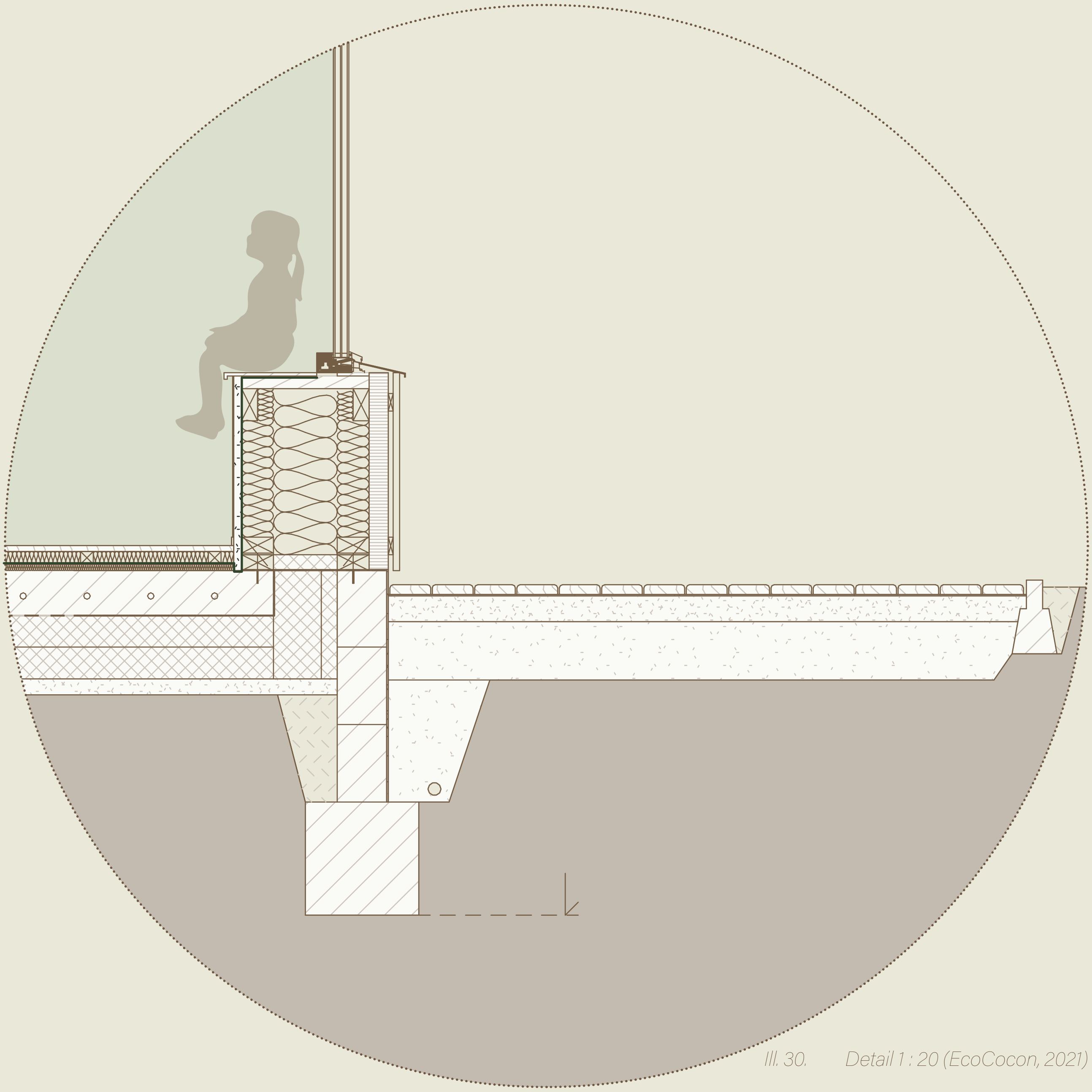


Ill. 28. EcoCocon timber-straw panel exploded view (EcoCocon, 2021)



Ill. 29. EcoCocon timber-straw panel properties (EcoCocon, 2021)

WALL AND FOUNDATION DETAIL
1 : 20



Ill. 30. Detail 1 : 20 (EcoCocon, 2021)

Wall:

3 mm	fine clay plaster
	reinforcing mesh
25 mm	base clay coat
	vapor barrier
400 mm	timber-straw panel
	air tight membrane
60 mm	wodden fiber board
35 mm	vertical wooden oak cladding

Floor:

20 mm	recycled gym parquet flooring
40 mm	screed with floor heating
	Vapor barrier
60 mm	insulation
140 mm	reinforced concrete slab
100 mm	PE sheet
100 mm	XPS insulation
50 mm	sand blinding

Ill. 31. Flow Mads-Emil 1 : 500

CHILD: A DAY AS MADS-EMIL

1. Arriving
2. Indoor free play
3. Prepare to go outside
4. Oudoor free play
5. Fruit break
6. Educational play
7. Lunch preparation
8. Lunch
9. Outdoor free play
10. Fruit break
11. Outdoor free play
12. Leaving

②

During Indoor free play, Mads-Emil is exploring his motorskills through play in the play tower. In case he needs a break he will pull himself back into one of the niches.

Ill. 32. Indoor free play common room

Ill. 33. *Bike trail*

④ During outdoor free play, Mads-Emil is playing with speed on the flat smooth surface of the kindergarten's bike track. He is racing against one of his friends.

Ill. 34. *Playground trail and hills*

⑨

After lunch, Mads-Emil spends time on tumble- and risky play. He utilizes the playground trail to climb and jump and the hills to roll and fall.

Ill. 35. Flow Albert-August 1 : 500

CHILD: A DAY AS ALBERT-AUGUST

1. Arriving
2. Indoor free play
3. Prepare to go outside
4. Oudoor free play
5. Fruit break
6. Educational play
7. Diaper change
8. Lunch
9. Sleeping
10. Outdoor free play
11. Fruit break
12. Outdoor free play
13. Leaving

Ill. 36. Green spaces for playing and hiding

④ During outdoor free play, Albert-August is exploring new areas and new types of play by hiding in the bushes. He brings his favorite toy car for comfort.

Ill. 37. Kitchen and common room

2 During indoor free play, Albert-August is practicing his creative skills by drawing. He will afterwards help the teacher cut up fruits for the fruit break

Ill. 38. Utilizing playroom as sleeping room

9

After lunch, Albert-August is preparing to take his afternoon nap. John is reading a story to him and the other children.

Ill. 39. Flow John 1 : 500

TEACHER: A DAY AS JOHN

1. Arriving
2. Indoor free play
3. Diaper change
4. Break time
5. Fruit break
6. Educational play
7. Diaper change
8. Lunch
9. Putting children to sleep
10. Outdoor free play
11. Waking up children
12. Fruit break
13. Animal care
14. Leaving (occasionally staff meeting)

⑥ Today John exploits the educational play to teach the children about biodiversity by creating insect hotels and hanging them on the fence.

Ill. 40. Insect hotels on fence

Ownership

Educational play or guided play supports children's curiosity, creativity, and development. Teachers and children utilize the workshop, common rooms, courtyard, and greenhouse to make creations. The northern fence at Overby Bakke kindergarten is devoted to those creations. Children hanging their own creations result in a sense of ownership in the build environment. While children attend kindergarten, they take better care of the facilities in the same way people take better care of their private equipment compared to public equipment. This is a benefit for the lifespan of the building. When the children grow up their creations might still hang in the kindergarten resulting in the grownups taking care of the building too.

Shared facilities invite the local community into the kindergarten, creating a sense of ownership for everybody.

The lifespan of the building is visualized through child hands. Each child who attends the kindergarten will mark their handprint with their name on the fence.
During the years, the handprint will expand making it exciting to revisit when growing up living in the local community.

Ill. 41. Handprints and ownership

Ill. 42. Shelters and campfire during fruit break

⑫ John starts a campfire prior to the afternoon fruit break where he will assist each child in baking their own snack

Ill. 43. Flow Charlotte 1 : 500

PARENT: A DAY AS CHARLOTTE

1. Arriving with child
2. Picking up child
3. Occasionally: Meeting
4. Occasionally: Taking a walk
5. Occasionally: Weekend animal care
6. Occasionally: Sleeping in shelters

Ill. 44. Entrance

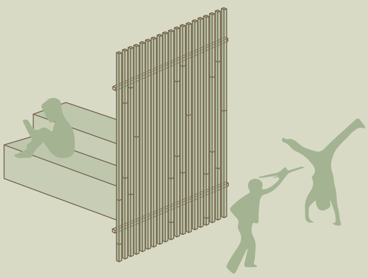
1 Charlotte will soon arrive with her son Mads-Emil and Albert-August. She will pack out their stuff in the wardrobe and register them on the screen in the wardrobe

Ill. 45. Wardrobe

② After work Charlotte picks up Mads-Emil and Albert-August. She will pack their bags in the wardrobe, register them as picked up and find them on the playground before going home for the day

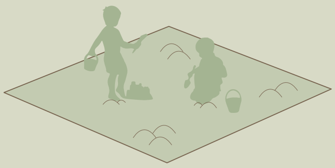
PRINCIPLES OF PLAY AREAS

Spaces within spaces



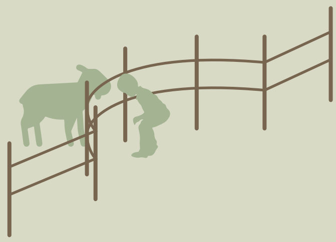
Ill. 46. Voluntary social interaction

Child lead free play



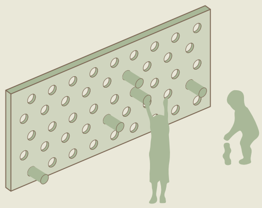
Ill. 47. Sandpit promoting development through pretend play and as moldable object

Independent engagement in shared facilities



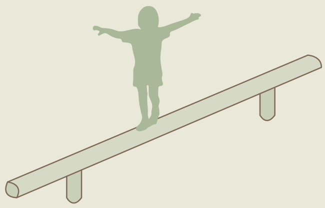
Ill. 48. Fence inviting the child to interact with animals when the teacher is not around

Interacting with build environment



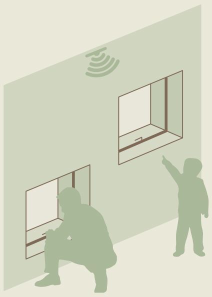
Ill. 49. Interactive elements in the building which changes expression while used

Build environment promoting child development



Ill. 50. Build environment promoting child development. Balance beam on playground promoting motor skills

Awareness of indoor climate - sensor based design



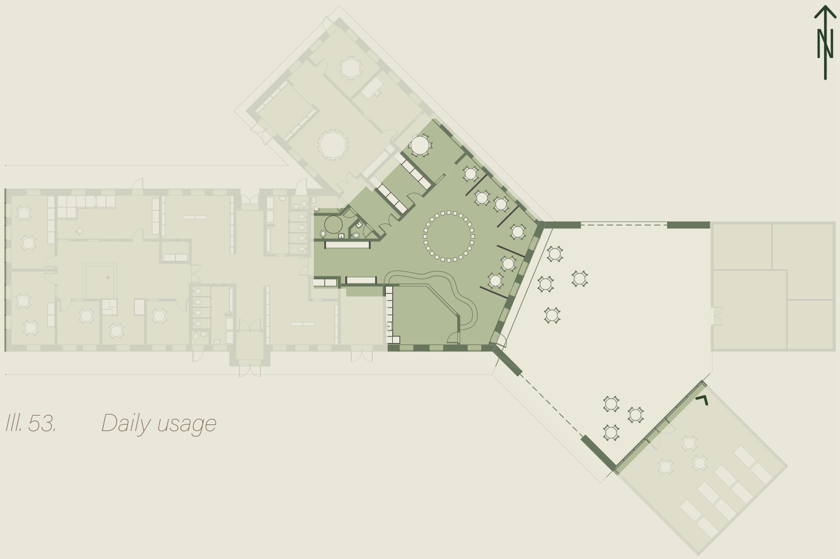
Ill. 51. Sensors showing when to open a window and when it is too loud

LOCAL COMMUNITY SHARED FACILITIES

Ill. 52. *Shared facilities*


Rainwater collection
Shelter Campfire
Biotank
Animals
Courtyard
Greenhouse
Fields
Workshop
Waste tank

LOCAL COMMUNITY EVERYDAY SCENARIOS

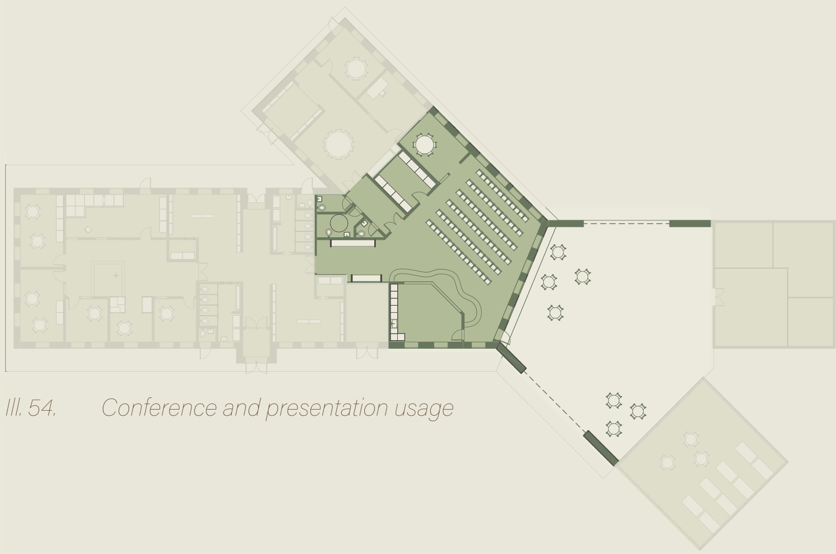


Ill. 53. *Daily usage*

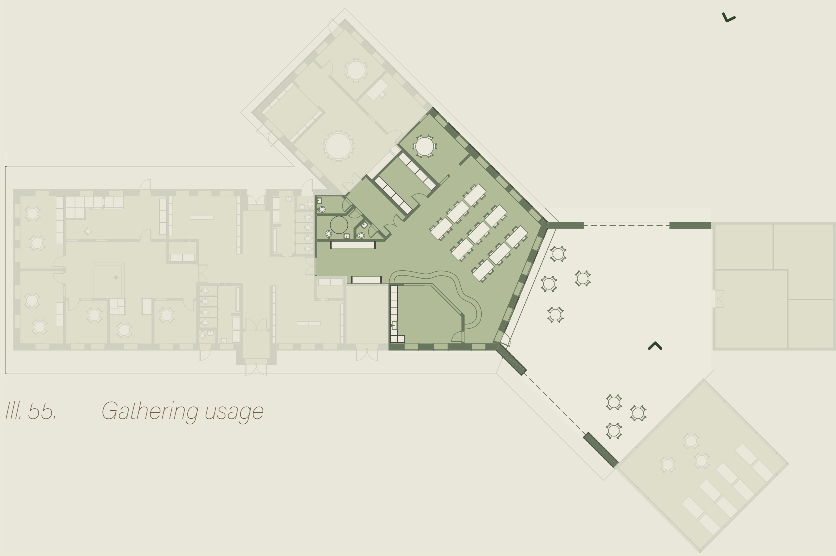
Utilizing the storage room, it is possible to arrange furniture differently in the common room. This makes the space flexible for different activities

Due to privacy regulations, a security boundary towards staff area, wardrobes and play area has been made.

Kitchen and staff toilets will be included in rental area to take advantage of functions.
The kitchen is by principle one of the most expensive rooms to construct and operate. Therefore, it is more efficient to be able to occupy the room during the kindergarten's unoccupied hours.



Ill. 54. *Conference and presentation usage*



Ill. 55. *Gathering usage*

Ill. 56. *Everyday scenario*

Everyday scenario

John is repotting plants with Mads-Emil while a local senior couple is joining Albert-August checking on the crops they planted together last week.

Ill. 57. *Weekend scenario*

Weekend scenario

Charlotte takes care of the animals while a senior from Overby Bakke waters the crops. A local citizen comes by to harvest some vegestables for her dinner.

A lady is taking a walk with her dog and greets her neighbours.

Ill. 58. *Evening scenario*

Evening scenario

Neighbours of Overby Bakke are renting the kindergarten for a get together barbeque.

A GREEN KINDERGARTEN

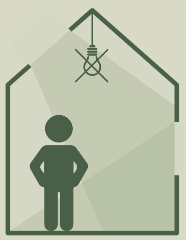
Green energy is the energy which is never produced. This is why Overby Bakke kindergarten is planned, from the beginning of the design, to have a greatly reduced energy demand reached by only passive strategies. These strategies ensure natural energy free of charge for both the environment and the developer of the building. This is possible by exploiting the microclimate in terms of wind, sun, rain, temperatures where the building is placed.

The passive strategies make it possible to reach low-energy building. To reach zero-energy building active strategies have been taken into consideration.

These strategies have been planned to be as efficient and sustainable as possible with the energy produced from renewable sources. Mechanical ventilation has been planned with a focus and respect for both the environment and the user's comfort.

Ill. 59. Sustainable strategies

ZERO ENERGY BUILDING
ENERGY CONSUMPTION
PASSIVE STRATEGIES

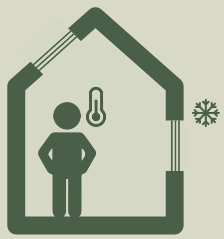


Daylight

It is possible to greatly reduce the demand of electric light due to a daylight factor above 2.5% on average.

Envelope

The envelope has a low U-value which reduces transmission loss. Furthermore, the envelope is tight, avoiding thermal bridges and line loss.

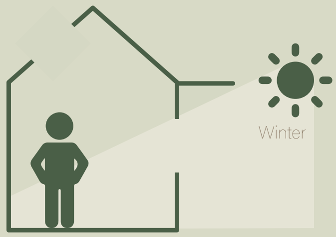


Windows and glazing

Three layered energy glazing has been implemented in the building to reduce the thermal loss through the glazing.

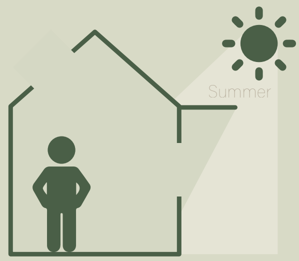
Natural ventilation

Natural ventilation has been implemented to reduce overheating. Smaller rooms utilize single sided ventilation. Bigger and greatly occupied rooms utilize skylights to achieve cross ventilation with thermal buoyancy which increases the air change in the room.



Passive solar heating

The kindergarten takes advantage of the sunlight in the winter months by allowing the heat from the sunlight into the building.



Passive solar shading

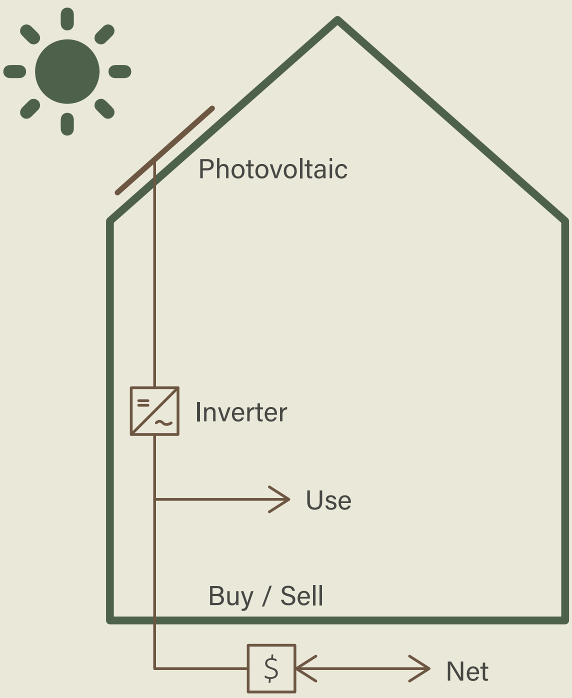
The overhang of the roof has been planned to create solar shading in the building during the summer month which prevents overheating.

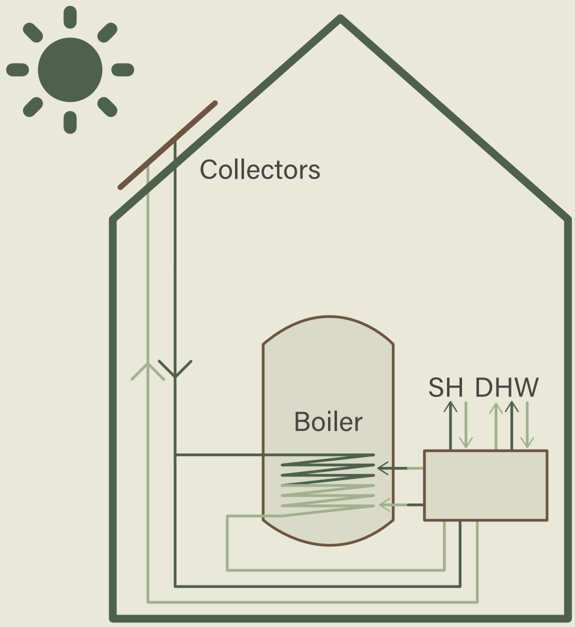
Ill. 60. Passive strategies

Energy consumption with passive strategies
(calculated with BE18)

25.8 / 27 kWh/m^2 year

ZERO ENERGY BUILDING
ENERGY CONSUMPTION
RENEWABLE RESOURCES





Photovoltaic
The photovoltaic solar cells creates electricity for the building by exploiting the solar radiation. As the sun is being an unreliable energy source, the photovoltaics are still calculated to cover most of the electricity demand *(calculated in appendix 4)*.
A battery to store energy is found in the technical room. This energy cannot be stored for more than a few weeks at a time.
More energy is produced in the summer than the winter. Therefore, the building is connected to the grid which makes it possible to buy or sell energy to the net.

Solar thermal collectors
The solar thermal collectors exploit solar radiation to heat up water used for domestic hot water or space heating. A system which sustains both has been chosen. The water tank is stored in the technical room *(calculated in appendix 5)*.

Energy consumption with active strategies
(calculated with BE18)

-9.2 / 0 kWh/m² year

Ill. 61. Renewable solutions (Marszal-Pomianowska, 2019)

INDOOR ENVIRONMENT USER COMFORT

The comfort of the occupant of Overby Bakke kindergarten is ensured through visual, thermal, atmospheric, and acoustic comfort.

Visual comfort is achieved by a daylight factor above 2.5% on average in each room. Common rooms and work surfaces have a daylight factor at 5% on average resulting in a natural light with no need for artificial light. Solar glare is avoided by placing offices towards north with diffuse light. Additionally, the windows are installed with a shading system which makes the user able to control the natural light.

Thermal- and atmospheric comfort is documented with a Bsim simulation, calculating the temperature four times an hour throughout a year. CO2 levels, monthly average temperatures, as well as summer- and winter solstice temperatures, compling with requirements for thermal comfort. This is due to the heating strategy as well as mechanical, and natural ventilation. Additionally, sensors are installed in each room. Connected to the temperature and CO2 sensor in the ventilation unit it is possible to measure these values and make the occupants aware of when it is time to open a window. This is a great way to create awareness of the indoor environment for the children.

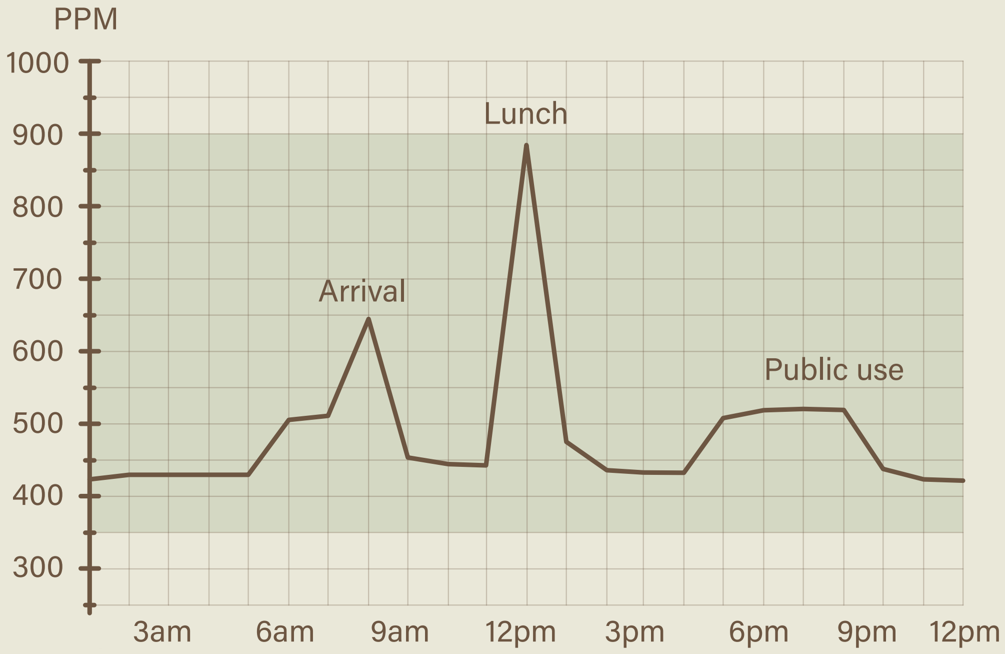
Acoustic comfort is documented by a reverberation time calculation in critical rooms ensuring a comfortable absorption of the sound. An acoustic sensor is installed in the common rooms to create awareness for the children of when the sound level can influence their health.

Daylight

Daylight factor above 2.5% on average

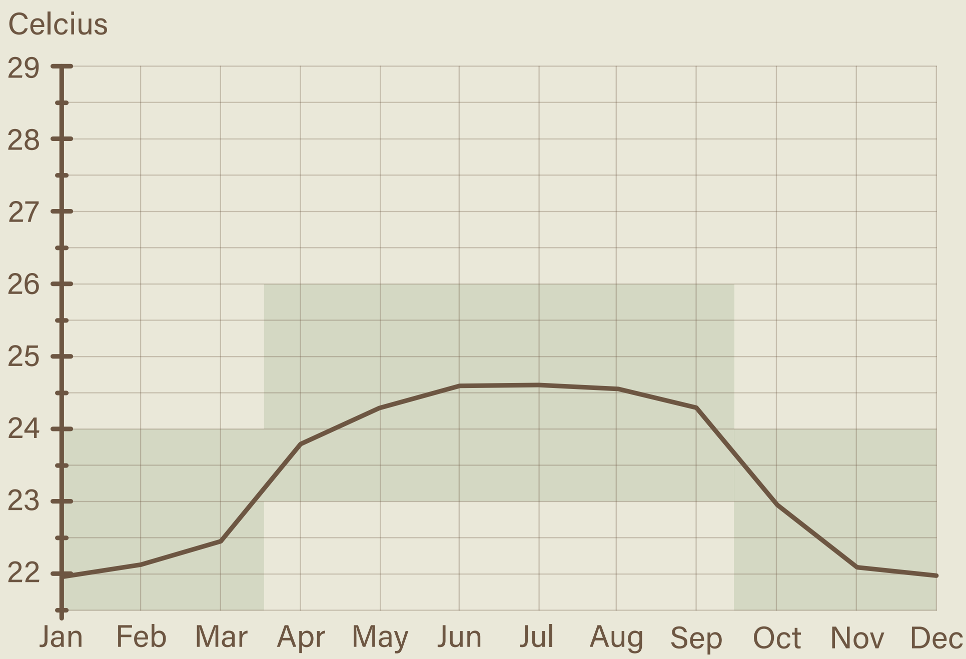
Ill. 62. Daylight factor analysis

Atmospheric comfort CO_2 levels



Ill. 63. Bsim simulation

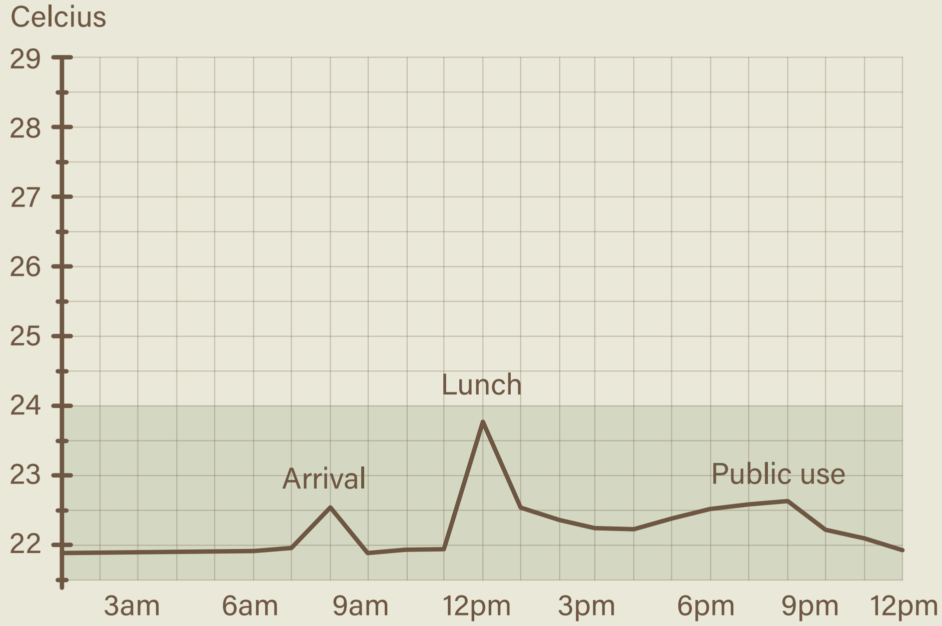
Thermal comfort month average temperatures



Ill. 64. Bsim simulation

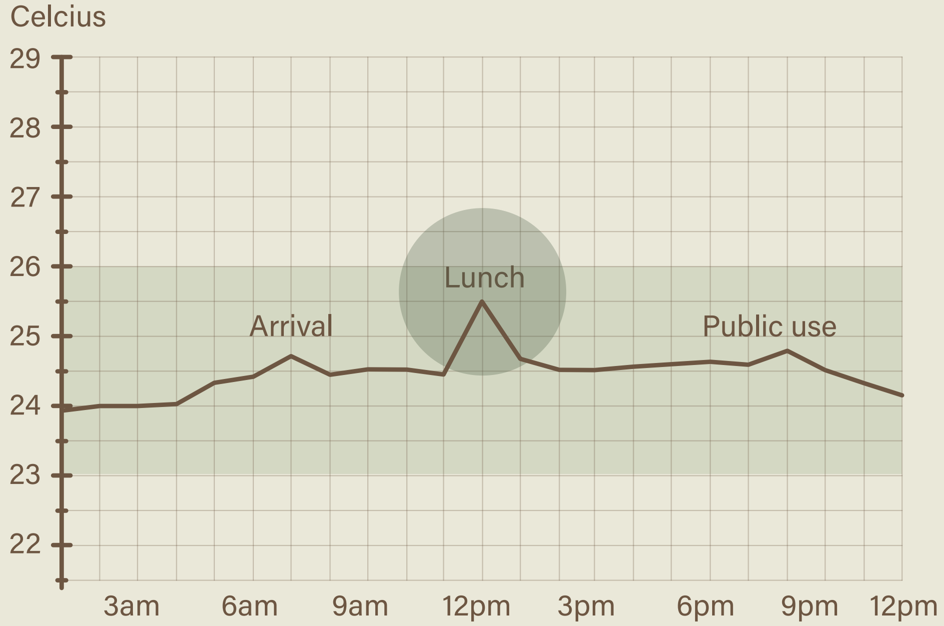
** green color indicate required values according to DGNB standards*

Thermal comfort winter solstice (20-24 °C)



Ill. 65. Bsim simulation

Thermal comfort summer solstice (23-26 °C)



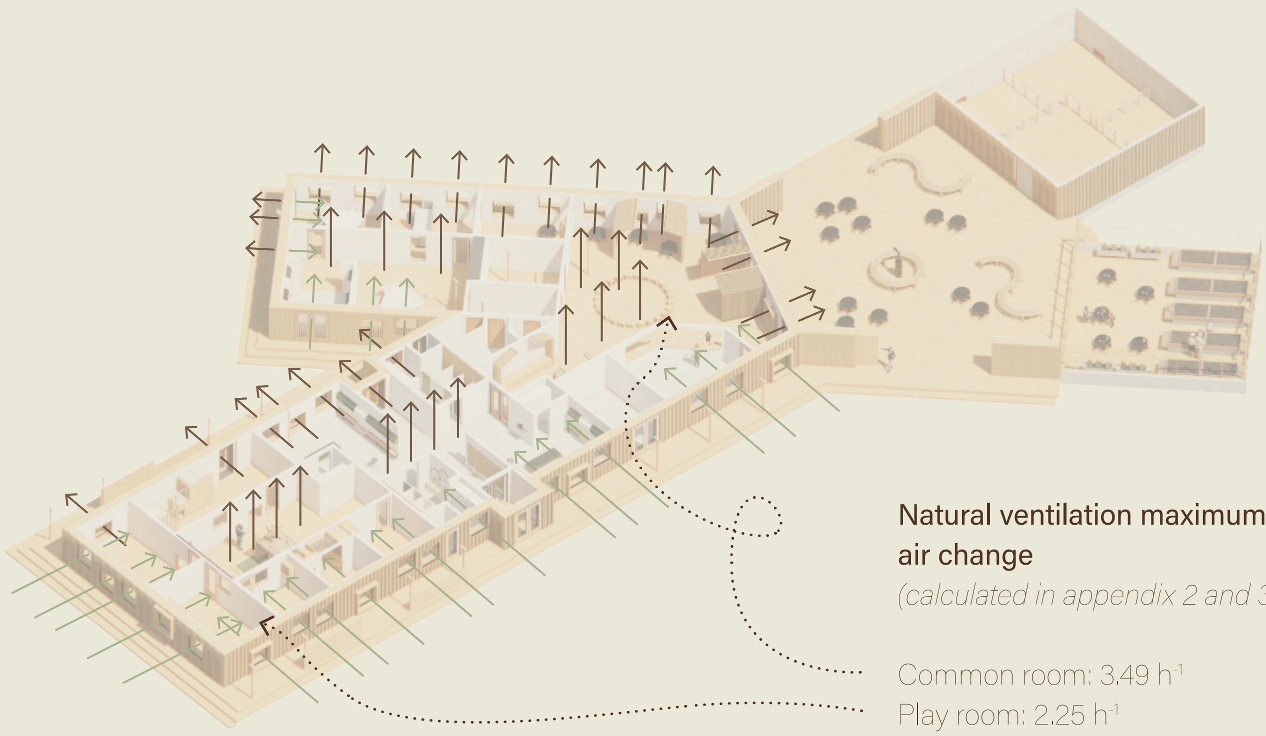
Ill. 66. Bsim simulation

Hours above 26 °C: **86**/100
Hours above 27 °C: **18**/25
Hours below 20 °C: **0**/0

NATURAL VENTILATION

Wind pressure with a major wind direction from the west has also been taken into consideration while designing for natural ventilation. A pressure is created on the faces of the building in the windward direction where a negative pressure is created on faces in the leeward direction. This knowledge has been used to map the direction of the air in the building *(see ill. 67).*
The air gets blown from outside towards inside on faces with pressure. It is therefore a benefit to design windows which open inward to exploit the natural flow of the wind. The opposite happens on faces with negative pressure where the wind naturally gets sucked out of the room. It is in this case important to design windows which open outwards.

Furthermore, it is important to not only consider outdoor pressure but also interior pressure in the room. By having a negative pressure inside, the air naturally flows out of the room, which allows fresh air, with minimal pollution, into the room.
Cross ventilation exploits this process since polluted air gets sucked out of the room while fresh air gets blown in.
Skylights make use of thermal buoyancy as well as negative pressure which makes natural ventilation even more efficient.



Natural ventilation maximum air change
(calculated in appendix 2 and 3)

Common room: 3.49 h^{-1}
Play room: 2.25 h^{-1}

Ill. 67. Natural ventilation air flow

MECHANICAL VENTILATION

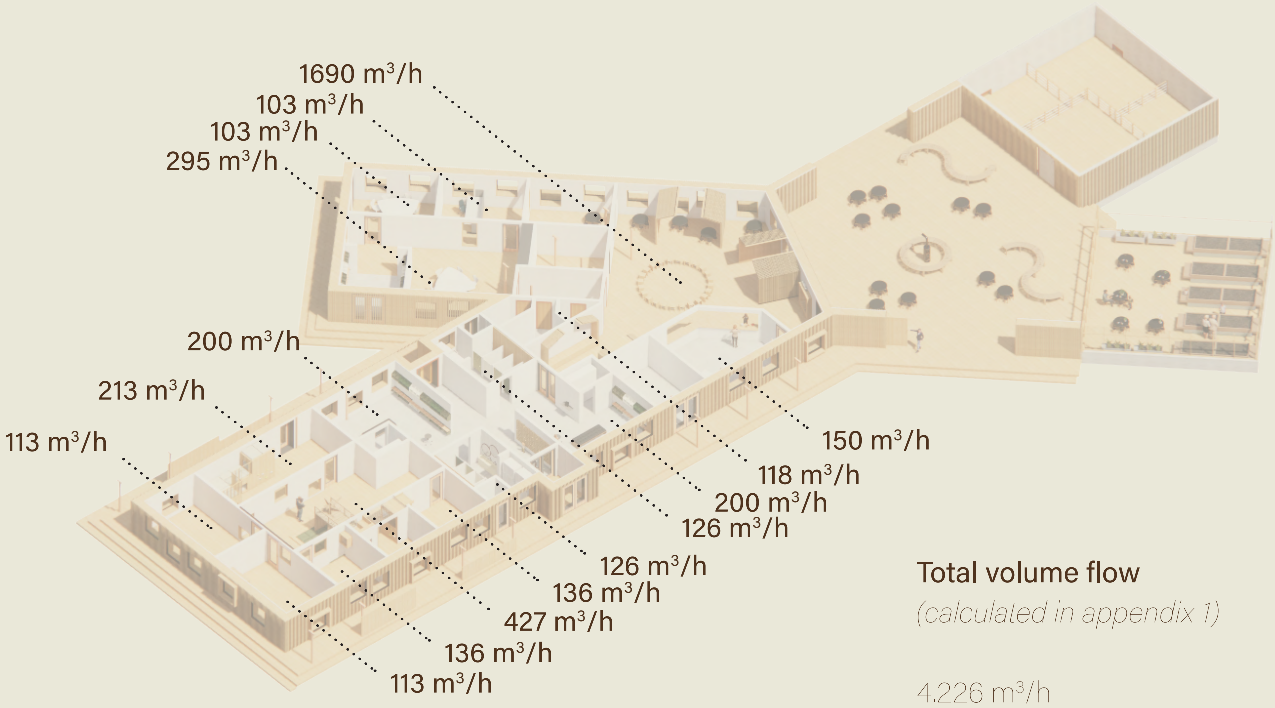
A mechanical ventilation system has been installed to ensure the occupant's comfort. Each rooms volume flow has been visualized on ill. 68. The volume flow in each room must be obtained to ensure a pleasant indoor environment.

Ventilation strategy

Mixing ventilation with both supply and exhaust has been chosen, since this is most efficient in case of fluctuating amounts of people, which can be the case for Overby Bakke kindergarten.

Ventilation control

VAV-control system has been chosen for the kindergarten. It is easy for the operators to change the settings of the ventilation when needed. The ventilation demand is fluctuating in a kindergarten due to a change in the amounts of people in each rooms. Therefore, sensors can contribute to the VAV-system, making it possible to adjust volume flow according to the specific demand.



Total volume flow

(calculated in appendix 1)

4.226 m³/h

Ill. 68. Mechanical ventilation volume flow

VENTILATION UNIT

Ventilation unit, Nilan VPR 480, has been chosen according to the total need of volume flow in the entire kindergarten (4.226 m^2/h). The company Nilan has been chosen since the product is produced in Denmark and therefore more sustainable according to transport.
Furthermore, the ventilation unit also complies with the possible settings required from the Bsim simulation process *(see ill. 69)*

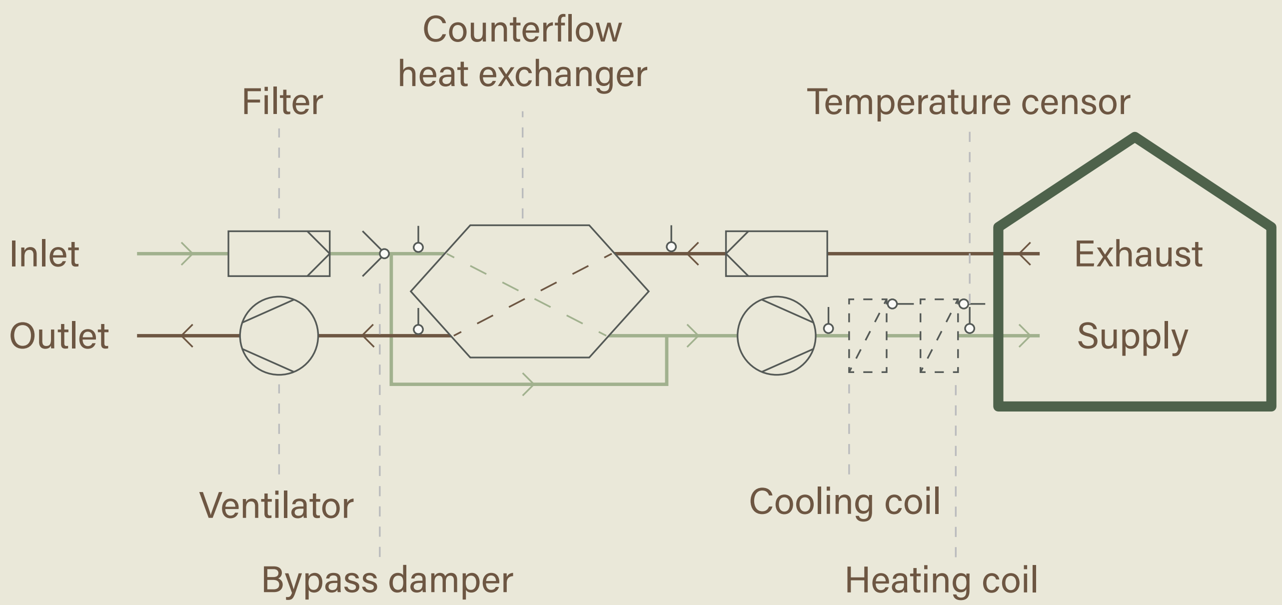
Counterflow heat exchanger utilizes the heated and polluted air to naturally heat up the fresh air before entering the room.

Bypass damper is used when it is not necessary to heat up the fresh air.

The ventilation unit is protected by two different filters. First a **G4 filter** which prevents dirt, dust, or grease from entering the system. Additionally, a **F9 filter** has been added to ensure a healthy environment for the occupants. This filter prevents pollen or other particles from entering the building, making a pleasant environment for all children, even those with allergies.

Temperature and CO_2 sensors are used to adjust the VAV-control and bypass damper as well as informing the users when it would be suitable to open a window.

Heating and cooling coil is a box of water which works as an addition to the counterflow heat exchanger.

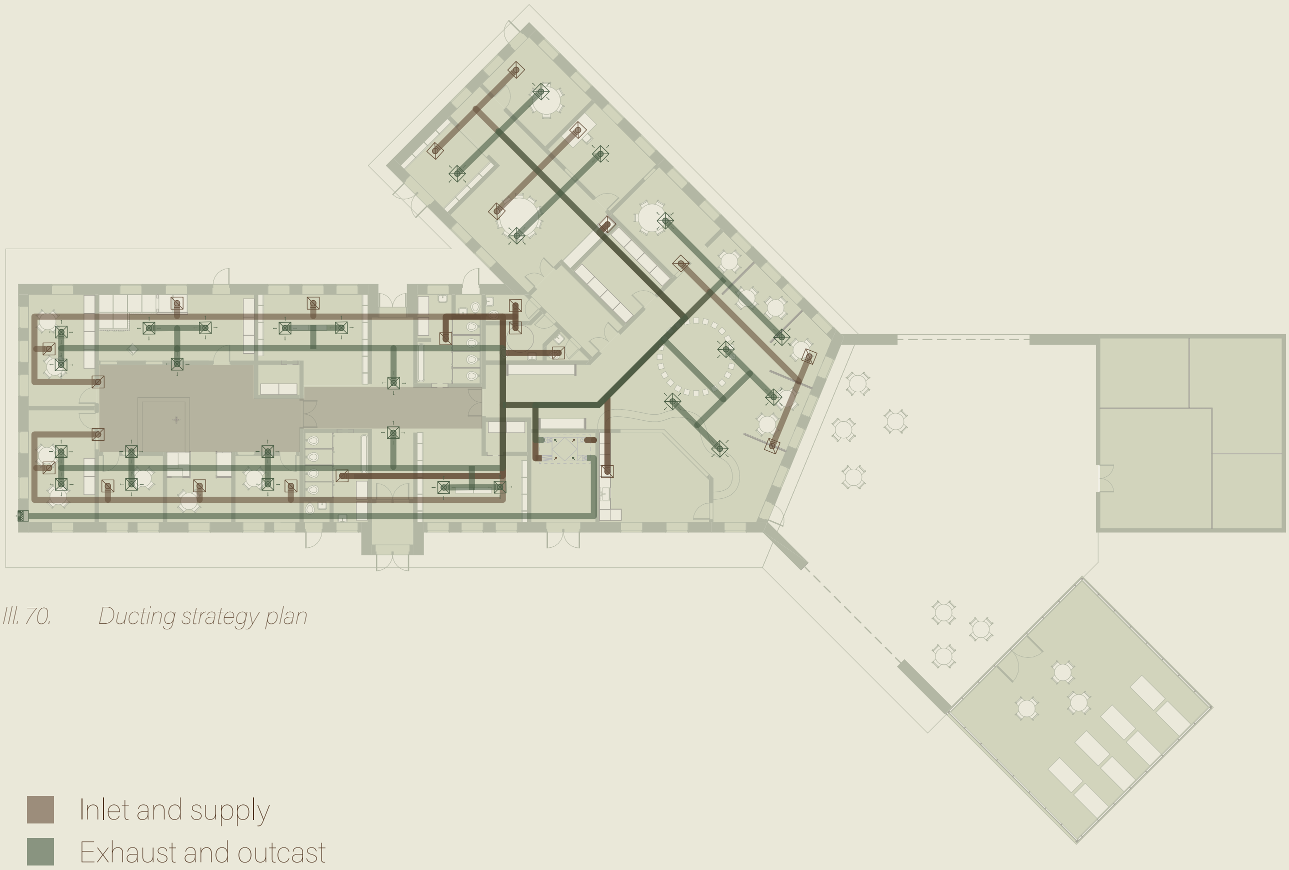


Ill. 69. Ventilation unit components

DUCTING

The supply ducts have been placed as efficient as possible creating a symmetrical flow which avoids the need for dampers. This makes it less likely for the occupants to feel draught in a room due to an even airflow from all supplies. The suspended ceiling in most of the building makes it possible to achieve a symmetrical flow with the shortest pipe length without compromising the architectural quality of the kindergarten. The ceiling system makes it possible to access the pipes in case of damage. Furthermore, the pressure loss in the system is also smaller when having shorter pipe length and less dampers, making it possible to have only one ventilation unit in the kindergarten, without exceeding the required SEL value.

It is not important to consider a symmetrical system for the exhaust pipe. Moreover, is it important to consider the flow of the air going from less polluted to more polluted rooms. Resulting in the exhaust pipes in the kindergarten flowing as follows: playroom – common room – kitchen – toilets – outside *(see ill. 70)*.



Ill. 70. Ducting strategy plan

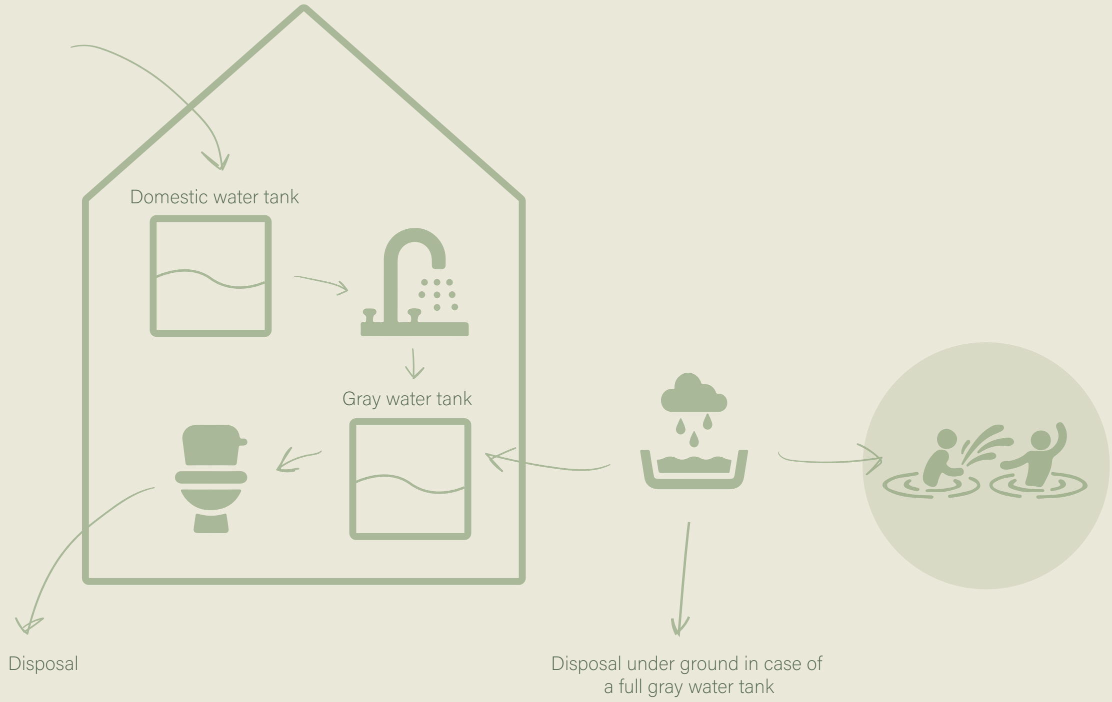
- Inlet and supply
- Exhaust and outcast
- Exposed ceiling without ducts

RAINWATER COLLECTION

Ill.71. Rainwater collection water play

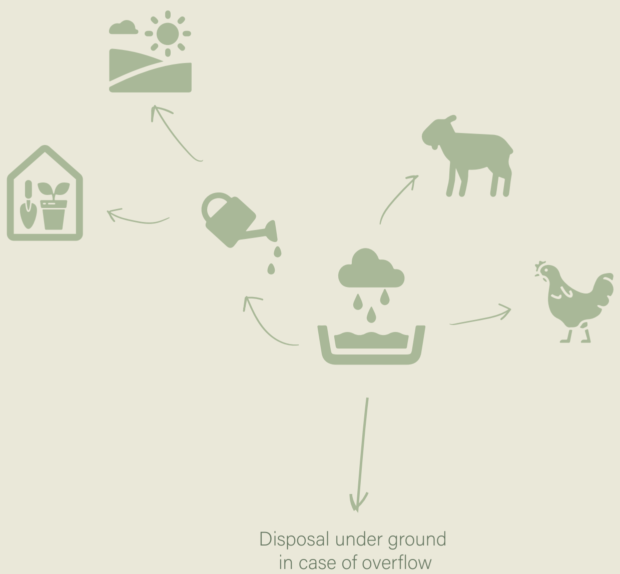
WATER MANAGEMENT

Main building



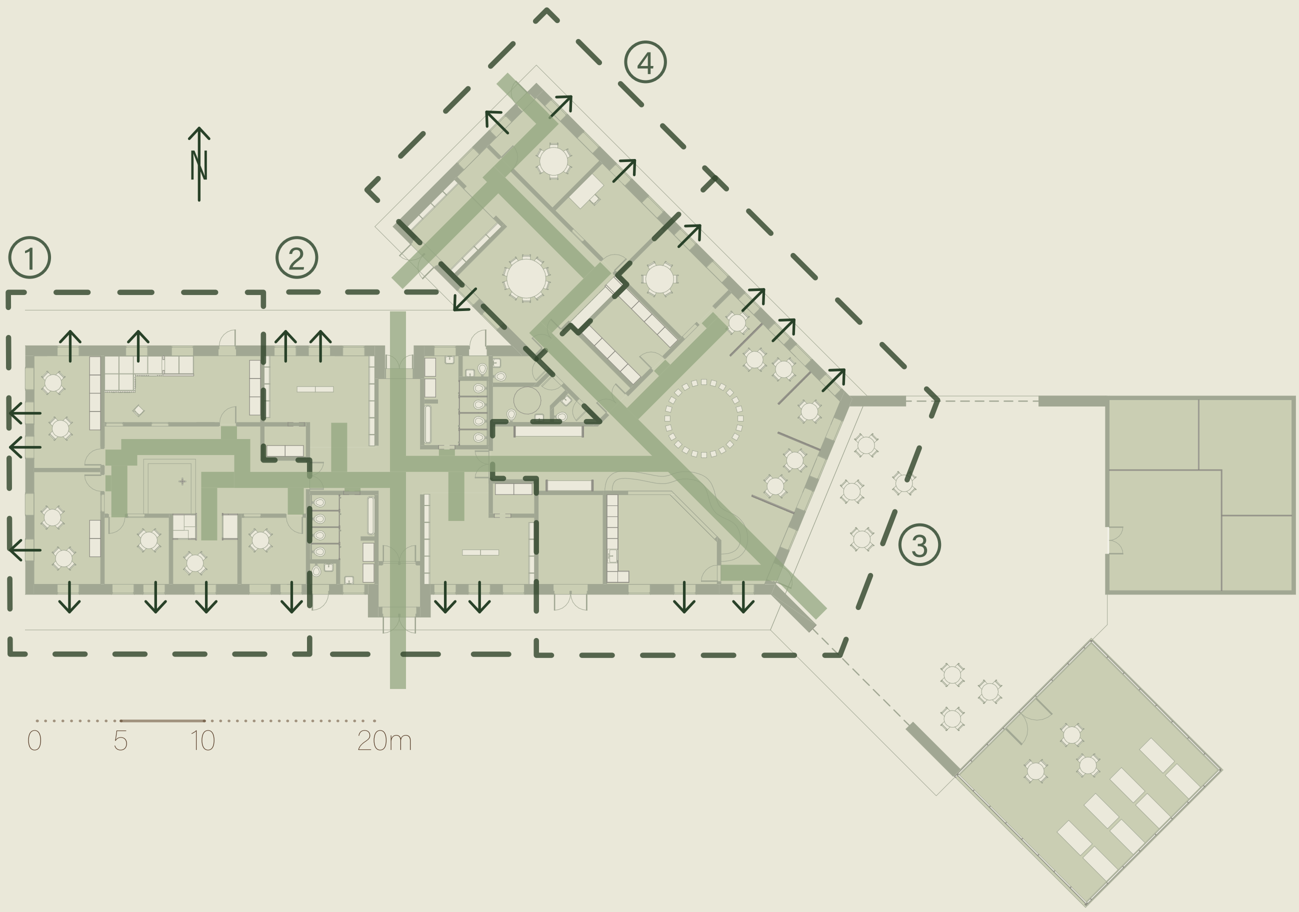
Ill. 72.   Water management main building

Greenhouse rainwater collection



Ill. 73.   Rainwater collection greenhouse

FIRE STRATEGY



Ill. 74. Fire strategy

Fire sections

The kindergarten is divided into four fire sections. Walls and doors between these sections are fireproofed and therefore fixed in the building.

Escape route

In case of a fire the escape route will not exceed 25 meters. Furthermore, each room in fire section 1, 3, and 4 have at least one window designed according to regulation of fire rescue openings.

REI 120 clasification

The EcoCocon Timber-Staw panels are tested and classified with fire resistance RE 120 / REI 120 / REW 120 in both direction interior and exterior *(Fires s. r. o., 2018)*. This means the building will sustain more than 120 minutes of fire without failure. This is crucial in a building with younger children.

Part 03

Part 02

Part 01

EPILOGUE

Conclusion
Reflection
Literature
Illustrations

CONCLUSION

Overby Bakke Kindergarten is a sustainable kindergarten designed with awareness on the everyday life of the occupants. The building exploits the country farming atmosphere of the area through the concept and typology.

The kindergarten is designed to initiate child lead play for everyone. It is achieved through affordances based on the design elements from Haft's preliminary functional taxonomy, which supports child development. The individual child can explore their personal skills through risky play. This is implemented as child lead play e.g., play tower and trail, and as guided play e.g., campfire, workshop area and farming.

Everyday scenarios have been documented with personas, ensuring interior and exterior of the kindergarten sustains long-term environments. This is achieved by assuring many different activities, for both the primary and secondary users. The building is designed with the opportunity to initate play and activity, depending on how the user perceives the build environment.

People from the local community in Overby Bakke are invited to use the building when it is not being occupied or used as a kindergarten. Farming facilities such as animals, crops, greenhouse, campfire, and common rooms will be a shared facility and responsibility, creating ownership for the community. This creates a meeting space and landmark in Overby Bakke with a sense of life and occupation. This occurs when the parents take care of animals in the weekends, seniors interact with the children during occupied hours, someone waters the field, or the common room is rented out for a gathering.

Social sustainability is highly considered during the design process to ensure both mental and physical wellbeing for the users. Sustainable solutions and strategies have been implemented through the sketching- and synthesis phase, based on DGNB criteria, ensuring visual-, atmospheric-, acoustic- and thermal comfort. These strategies have been justified by the function, flow, and mental wellbeing of the occupants.

REFLECTION

Process

Utilizing the integrated design process has been a great tool to structure and manage the project. Structuring and documenting the entire project accordingly creates an awareness on where different elements of the design are in the process. Knowing how many loops a design has been through visualizes which elements to focus on in upcoming times.

Both engineering and architectural methods have been considered equally from the beginning of the project. The outcome of this is that both methods are working collaboratively with each other, not against each other, which can occur if not considered equally. This has resulted in a building with integrated functions in which both engineering and architectural values compliment each other. E.g., rainwater collection, daylight, acoustic/ visual room dividers, etc.

The virtual reality BIM-model shifted some of the work from the presentation phase to the sketching- and synthesis phase. By making an effort to develop a smart model in the beginning pays off during design changes and workshops in which materials and shapes can easily be investigated. Furthermore, the virtual reality BIM-model acted as an effective tool to understand reality in 4D. By having a smart model, it was possible to investigate design solutions, such as different wall materials and window openings.

Group dynamic

Being in a single-person group for the first time, resulted in ongoing adjustments of the workflow. While adjusting the workload adequate for one person, it has been important to consider what is important and why. It has been difficult to understand the specific boundary of how much to go in depth in certain subjects, without negatively influencing the workload. The concept and design objectives as well as the "design focus"-workshop acted as a personal tool to justify what is important to go in depth with. Furthermore, only the critical rooms of the building have been further investigated and detailed. Using acquired knowledge to apply similar strategies to the rest of the building.

Being a single-person group, it has been easier to make decisions during the design process. However, on occasion it has been difficult be critical on decisions made, which is why it could have been beneficial to work in a larger group. Therefore, to solve this, new methods were taken into consideration. Workshops acted as a tool to acquire enough knowledge and solutions to justify decisions. The integrated design process has been used while hosting workshops, which acts as the driver to backtrack through the phases. The theory gathered from the problem phase has been used as a reasoning for whether design solution would be implemented or not. Not being able to collaborate with teammates automatically creates a stronger bond to the conducted data, which improved the design.

Result

Knowledge and experience have been acquired exponentially during the last 10 semesters of studying engineering architecture. This leads to an understanding of principles of architectural and engineering methods on another level than previously – why it has been possible to go in depth with certain areas of the design, due to being able to predict the outcome of the visualization or calculation. Understanding different principles and strategies avoids wasting time on deficient designs, simulations, or calculations.

LITERATURE

Books, articles, journals, ect.

Bies, Hansen (1988) *Engineering noise control.* [online via internal VLE], Aalborg University. Last accessed: 17.05.2021

Dansk Standard: (2001) *DS/CEN/CR 1752 Ventilation i bygninger - projekteringskriterier for indeklimaet.* page 12-16, 107. 1. edition. Dansk Standard

Green Building Council Denmark (2017) *DGNB system Denmark* (1. edition) Copenhagen

Internet sources

EcoCocon (2021) *Assembly guide.* Last accessed: 13.05.2021 https://ecococon.eu/assets/downloads/c7a-assembly-guide.pdf

EcoCocon (2021) *Et modulsystem designet af naturen.* Last accessed: 13.05.2021
https://ecococon.eu/dk/element

EcoCocon (2021) *For architects.* Last accessed: 12.05.2021 https://ecococon.eu/assets/downloads/ecococon-brochure.pdf

EcoCocon (2021) *Passivehaus DETAILS.* Last accessed: 13.05.2021 https://ecococon.eu/assets/downloads/ph-certified-details-ecococon.pdf

Emdén, Teodor Javanaud (2021) *Skalgubbar.* Last accessed: 17.05.2021 https://skalgubbar.se/

Fires s. r. o. (2018) *Classification of fire restrictions in accordance with EN 13501-2: 2016 – with direct field of application fires-cr-015-18-AUPE.* Last accessed 18.05.2021
https://ecococon.eu/assets/downloads/ecococon-classification-rei-120-and-rei-120ef-(en).pdf

Heiselberg (2019) Zero energy buildings: *Modeling of natural ventilation and hybrid ventilation 1/2,* Lecture 11 MSc01-arch 2019 [online via internal VLE], Aalborg University. Last accessed: 17.05.2021

Larsen (2018) Husbyggeri 2: *Hygrotermisk bygningsfysik,* Lecture 1 BSc05-arch 2018 [online via internal VLE], Aalborg University. Last accessed: 17.05.2021

Marszal-Pomianowska (2019) Zero energy buildings: *Introduction to integrated design, Zero energy Buildings and Definitions. Energy producing technologies,* Lecture 1 MSc01-arch 2019 [online via internal VLE], Aalborg University. Last accessed: 17.05.2021

Nilan A/S (2021) *VPR 480.* Last accessed: 17.05.2021 https://www.nilan.dk/produkter/ventilation-med-koel-varme/varmepumpe-og-roterende-veksler/vpr-480

Vinci Play (2021) *Robinia series.* Last accessed: 19.05.2021 https://www.vinci-play.com/en/playground-equipment/robinia

ILLUSTRATIONS

Illustrations which are not mentioned in this list are owned or created by Ida-Katrine Arend Grün Hansen

Ill. 16 - Recycled gym floor
*Downloaded at Unsplash.com**

Ill. 17 and 21 - Concrete
*Downloaded at Unsplash.com**

Ill. 18 - Plywood
*Downloaded at Unsplash.com**

Ill. 19 - Clay plaster
*Downloaded at Unsplash.com**

Ill. 20 - Thermal oak cladding
*Downloaded at Unsplash.com**

Ill. 22 - Polycarbonat
*Downloaded at Unsplash.com**

Ill. 23 - Pea stone
*Downloaded at Unsplash.com**

Ill. 24 - White clover
*Downloaded at Unsplash.com**

Ill. 25 - Cone flower and daisy
*Downloaded at Unsplash.com**

Ill. 26 - Moss carpet
*Downloaded at Unsplash.com**

Ill. 27 - Texas sedge grass
*Downloaded at Unsplash.com**

** "Unsplash grants you an irrevocable, nonexclusive, worldwide copyright license to download, copy, modify, distribute, perform, and use photos from Unsplash for free, including for commercial purposes, without permission from or attributing the photographer or Unsplash." (Unsplash, [https://unsplash.com/license]. Last accessed 19.05.2021)*

APPENDIX

Part 03

Part 02

Part 01

APPENDIX 01
AIR CHANGE AND VOLUME FLOW

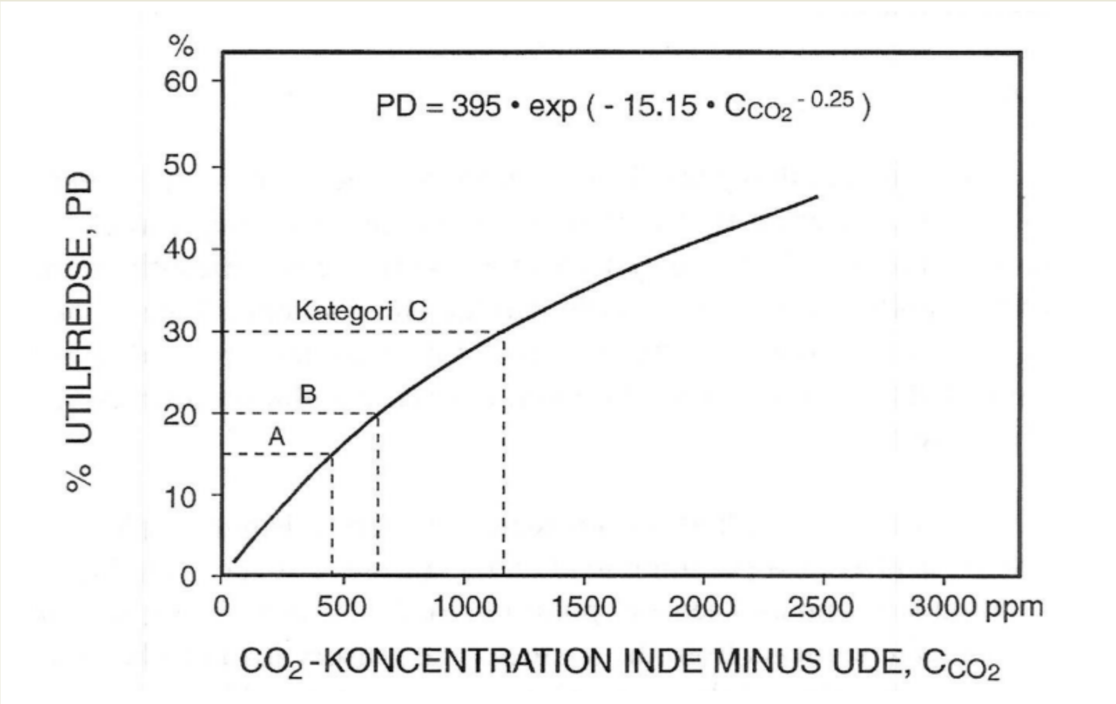
Outdoor polution

$ci := 350 :$

Polution indoor subtracted outdoor polution

$c_0 := 650 :$

Reading c_0 (Category B)



Category B *(DS 1752)*

Calculation of q with 3, 5, 10 and 50 persons

q (Breathing of CO2) Calculated with 17 times M, which is activity level in MET

q (Breathing of CO2) Unit: l/h, Wanted unit: m^3/h and therefore divided by 1000

$M := 1.2 :$

$$q_3 := \frac{17 \cdot M}{1000} \cdot 3 = 0.06120000000$$

$$q_5 := \frac{17 \cdot M}{1000} \cdot 5 = 0.1020000000$$

$$q_{10} := \frac{17 \cdot M}{1000} \cdot 10 = 0.2040000000$$

$$q_{50} := \frac{17 \cdot M}{1000} \cdot 50 = 1.020000000$$

Volume flow based on CO_2

Not subtracting the outside from c0. This value is maximum value OVER outside air (VL is volume flow)

$$VL3 := \frac{q_3}{c_0 \cdot 10^{-6}} = \; = 94.15384615$$

$$VL5 := \frac{q_5}{c_0 \cdot 10^{-6}} = 156.9230769$$

$$VL10 := \frac{q_{10}}{c_0 \cdot 10^{-6}} = 313.8461538$$

$$VL50 := \frac{q_{50}}{c_0 \cdot 10^{-6}} = 1569.230769$$

Areas

$A1 := 23 :$
$A2 := 14 :$
$A3 := 33 :$
$A4 := 66 :$
$A5 := 28 :$
$A6 := 19 :$
$A7 := 44 :$
$A8 := 138 + 19 :$
$A9 := 28 :$
$A10 := 16 :$
$A11 := 51 + 14 :$
$A12 := 10 :$

$h := 2.8 :$

Volumes

$V1 := A1 \cdot h = 64.4$
$V2 := A2 \cdot h = 39.2$
$V3 := A3 \cdot h = 92.4$
$V4 := A4 \cdot h = 184.8$
$V5 := A5 \cdot h = 78.4$
$V6 := A6 \cdot h = 53.2$
$V7 := A7 \cdot h = 123.2$
$V8 := A8 \cdot h = 439.6$
$V9 := A9 \cdot h = 78.4$
$V10 := A10 \cdot h = 44.8$
$V11 := A11 \cdot h = 182.0$
$V12 := A12 \cdot h = 28.0$

Air change based on CO_2

$$Airchange1 := \frac{VL3}{V1} = \mathbf{1.462016245} \frac{m^3}{h}$$

$$Airchange2 := \frac{VL3}{V2} = \mathbf{2.401883830} \frac{m^3}{h}$$

$$Airchange3 := \frac{VL5}{V3} = \mathbf{1.698301698} \frac{m^3}{h}$$

$$Airchange4 := \frac{VL10}{V4} = \mathbf{1.698301698} \frac{m^3}{h}$$

$$Airchange5 := \frac{VL5}{V5} = \mathbf{2.001569858} \frac{m^3}{h}$$

$$Airchange6 := \frac{VL3}{V6} = \mathbf{1.769809138} \frac{m^3}{h}$$

$$Airchange7 := \frac{VL3}{V7} = \mathbf{0.7642357642} \frac{m^3}{h}$$

$$Airchange8 := \frac{VL50}{V8} = \mathbf{3.569678728} \frac{m^3}{h}$$

$$Airchange9 := \frac{VL3}{V9} = \mathbf{1.200941915} \frac{m^3}{h}$$

$$Airchange10 := \frac{VL3}{V10} = \mathbf{2.101648352} \frac{m^3}{h}$$

$$Airchange11 := \frac{VL5}{V11} = \mathbf{0.8622147082} \frac{m^3}{h}$$

$$Airchange12 := \frac{VL3}{V12} = \mathbf{3.362637362} \frac{m^3}{h}$$

Volume flow based on smell

To optain category B it is only allowed to have 20% unsatisfaction.
It means a maximum of 1.4 decipol polution
$c := 1.4 :$

q is calcuated with the unit olf. One person smells 1 olf. The building smells 0.1olf/m^2

$$q1 := 3 + (0.1 \cdot A1) = \mathbf{5.3}\, h^{-1}$$
$$q2 := 3 + (0.1 \cdot A2) = \mathbf{4.4}\, h^{-1}$$
$$q3 := 5 + (0.1 \cdot A3) = \mathbf{8.3}\, h^{-1}$$
$$q4 := 10 + (0.1 \cdot A4) = \mathbf{16.6}\, h^{-1}$$
$$q5 := 5 + (0.1 \cdot A5) = \mathbf{7.8}\, h^{-1}$$
$$q6 := 3 + (0.1 \cdot A6) = \mathbf{4.9}\, h^{-1}$$
$$q7 := 3 + (0.1 \cdot A7) = \mathbf{7.4}\, h^{-1}$$
$$q8 := 50 + (0.1 \cdot A8) = \mathbf{65.7}\, h^{-1}$$
$$q9 := 3 + (0.1 \cdot A9) = \mathbf{5.8}\, h^{-1}$$
$$q10 := 3 + (0.1 \cdot A10) = \mathbf{4.6}\, h^{-1}$$
$$q11 := 5 + (0.1 \cdot A11) = \mathbf{11.5}\, h^{-1}$$
$$q12 := 3 + (0.1 \cdot A12) = \mathbf{4.0}\, h^{-1}$$

The smelling air from outside is chosen to be 0, because of no air outside

$cis := 0 :$

Multiply by 3.6 to change the unit from l/s to m^3/h

$$c = \left(10 \cdot \frac{q1}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{136.2857143} \frac{m^3}{h}$$

$VLs1 := 136.29 :$

$$c = \left(10 \cdot \frac{q2}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{113.1428571} \frac{m^3}{h}$$

$VLs2 := 113.14 :$

$$c = \left(10 \cdot \frac{q3}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{213.4285714} \frac{m^3}{h}$$

$VLs3 := 213.43 :$

$$c = \left(10 \cdot \frac{q4}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{426.8571429} \frac{m^3}{h}$$

$VLs4 := 426.86 :$

$$c = \left(10 \cdot \frac{q5}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{200.5714286} \frac{m^3}{h}$$

$VLs5 := 200.57 :$

$$c = \left(10 \cdot \frac{q6}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{126.} \frac{m^3}{h}$$

$VLs6 := 126 :$

$$c = \left(10 \cdot \frac{q7}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{190.2857143} \frac{m^3}{h}$$

$VLs7 := 190.29 :$

$$c = \left(10 \cdot \frac{q8}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{1689.428571} \frac{m^3}{h}$$

$VLs8 := 1689.43 :$

$$c = \left(10 \cdot \frac{q9}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{149.1428571} \frac{m^3}{h}$$

$VLs9 := 149.14 :$

$$c = \left(10 \cdot \frac{q10}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{118.2857143} \frac{m^3}{h}$$

$VLs10 := 118.29 :$

$$c = \left(10 \cdot \frac{q11}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{295.7142857} \frac{m^3}{h}$$

$VLs11 := 295.71 :$

$$c = \left(10 \cdot \frac{q12}{VL} + cis\right) \cdot 3.6 \xrightarrow{\text{solutions for VL}} \mathbf{102.8571429} \frac{m^3}{h}$$

$VLs12 := 102.86 :$

Air change based on smell

$$n1 := \frac{VLs1}{V1} = \mathbf{2.116304348}\ h^{-1}$$

$$n2 := \frac{VLs2}{V2} = \mathbf{2.886224490}\ h^{-1}$$

$$n3 := \frac{VLs3}{V3} = \mathbf{2.309848485}\ h^{-1}$$

$$n4 := \frac{VLs4}{V4} = \mathbf{2.309848485}\ h^{-1}$$

$$n5 := \frac{VLs5}{V5} = \mathbf{2.558290816}\ h^{-1}$$

$$n6 := \frac{VLs6}{V6} = \mathbf{2.368421053}\ h^{-1}$$

$$n7 := \frac{VLs7}{V7} = \mathbf{1.544561688}\ h^{-1}$$

$$n8 := \frac{VLs8}{V8} = \mathbf{3.843107370}\ h^{-1}$$

$$n9 := \frac{VLs9}{V9} = \mathbf{1.902295918}\ h^{-1}$$

$$n10 := \frac{VLs10}{V10} = \mathbf{2.640401786}\ h^{-1}$$

$$n11 := \frac{VLs11}{V11} = \mathbf{1.624780220}\ h^{-1}$$

$$n12 := \frac{VLs12}{V12} = \mathbf{3.673571429}\ h^{-1}$$

A ventilation system has been chosen from the volume flow of the biggest of CO_2 polution or smell. The values evens to the grater size.

Airflow in building m^3/h:

$$VLs1 + VLs1 + VLs2 + VLs2 + VLs3 + VLs4 + VLs5 + VLs5 + VLs6 + VLs6 + VLs7 + VLs8 + VLs9 + VLs10 + VLs11 + VLs12 + VLs12 = \mathbf{4440.87}\ \frac{m^3}{h}$$

Airchange in building l/s:

$$n1 + n1 + n2 + n2 + n3 + n4 + n5 + n5 + n6 + n6 + n7 + n8 + n9 + n10 + n11 + n12 + n12 = \mathbf{43.38046823}\ h^{-1}$$

APPENDIX 02
MAXIMUM NATURAL VENTILATION
COMMON ROOM

$$p_u := 1.205 : \textit{(Heiselberg, 2019)}$$
$$v_{ref} := 7 : \textit{(ibid.)}$$
$$A_1 := (1.25 \cdot 1.25) \cdot 13 = 20.3125$$
$$A_2 := (1.25 \cdot 1.25) \cdot 5 = 7.8125$$
$$C_{p1} := -0.8 : \textit{(ibid.)}$$
$$C_{p2} := -0.38 : \textit{(ibid.)}$$

$$p_i := \frac{1}{2} \cdot p_u \cdot v_{ref}{}^2 \cdot \left(\frac{A_1{}^2 \cdot C_{p1} + A_2{}^2 \cdot C_{p2}}{A_1{}^2 + A_2{}^2} \right) = -\mathbf{22.02013274Pa}$$

$$C_{d2} := 0.7 : \textit{(ibid.)}$$

$$AirVelocity := \sqrt{p_u \cdot C_{d2} \cdot A_1 \left(\frac{C_{p1} \cdot p_u \cdot v_{ref}{}^2 - 2 \cdot p_i}{p_u} \right)^{\frac{1}{2}}} + \sqrt{p_u \cdot C_{d2} \cdot A_2 \left(\frac{C_{p2} \cdot p_u \cdot v_{ref}{}^2 - 2 \cdot p_i}{p_u} \right)^{\frac{1}{2}}} \quad \mathbf{3.485235477}\ \boldsymbol{h^{-1}}$$

Negative pressure: -22Pa
Air change 3.49h^{-1}

APPENDIX 03
MAXIMUM NATURAL VENTILATION
PLAY ROOM

$p_u := 1.205$: *(ibid.)*

$v_{ref} := 7$: *(ibid.)*

$A_1 := (1.25 \cdot 1.25) \cdot 2 = 3.1250$

$A_2 := (1.25 \cdot 1.25) \cdot 1 = 1.5625$

$C_{p1} := 0.7$: *(ibid.)*

$C_{p2} := -0.5$: *(ibid.)*

$$p_i := \frac{1}{2} \cdot p_u \cdot v_{ref}^2 \cdot \left(\frac{A_1^2 \cdot C_{p1} + A_2^2 \cdot C_{p2}}{A_1^2 + A_2^2} \right) = \mathbf{13.58035000 Pa}$$

$C_{d2} := 0.7$: *(ibid.)*

$$AirVelocity := \sqrt{p_u \cdot C_{d2} \cdot A_1 \left(\frac{C_{p1} \cdot p_u \cdot v_{ref}^2 - 2 \cdot p_i}{p_u} \right)^{\frac{1}{2}}} + \sqrt{p_u \cdot C_{d2} \cdot A_2 \left(\frac{C_{p2} \cdot p_u \cdot v_{ref}^2 - 2 \cdot p_i}{p_u} \right)^{\frac{1}{2}}} \quad \mathbf{2.247938373} \; \boldsymbol{h^{-1}}$$

Pressure: 13.58Pa
Air change 2.25h^{-1}

APPENDIX 04
AMOUNT OF PHOTVOLTAICS

Electric consumption

$ElectricConvertFactor := 1.9 :$

$Elcomp := 51.9 \cdot ElectricConvertFactor + 25.1 = 123.71$ kWh/m2 year

Needed electric solar covering

$BuildingSize := 673 :$ m2

$$SC := \frac{Elcomp}{ElectricConvertFactor} = 65.11052632 \text{ kWh/m2 year}$$

$SolarC := SC \cdot BuildingSize = \mathbf{43819.38421}$ **kWh year**

Peak power

$SystemFactor := 0.8 :$

$SolarRadS := 999 :$

$AreaSolar := \mathbf{30} :$

$$SolarC = effect \cdot SystemFactor \cdot SolarRadS \xrightarrow{\text{solutions for effect}} 54.82905932$$

$Effect := 54.83 :$

$$PeakPower := \frac{Effect}{AreaSolar} = \mathbf{1.827666667} \ \mathbf{< 5}$$

The electric consumption can be covered with 30 m^2 photovoltaic panels with a peak power os 1.83 kWp

APPENDIX 05
AMOUNT OF SOLAR THERMAL COLLECTORS

Domestic Hot Water - consumption - Dimensioning

1.0-1.5 m^2 Thermal Collectors is needed for each 30 liter of the tanks

$TankVolume := 200 :$

$$\frac{1.5}{30} = 0.05000000000$$

$0.05 \cdot TankVolume = \mathbf{10.00}\ \boldsymbol{m^2}$ Thermal Collectors are needed to cover the tank

Rain water collection - consumption - Dimensioning

1.0-1.5 m^2 Thermal Collectors is needed for each 30 liter of the tanks

$TankVolume := 400 :$

$$\frac{1.5}{30} = 0.05000000000$$

$0.05 \cdot TankVolume = \mathbf{20.00}\ \boldsymbol{m^2}$ Thermal Collectors are needed to cover the tank

APPENDIX 06
U-VALUE CALCULATION

The wall is constructed of:
3 mm plaster(p)
reinforces mesh
25 mm base clay coat(c)
Vapor barrier
400 mm Timber-Straw panel (i)
Air tight membrane
60 mm wooden fiber board (b)
35 mm oak thermal wood cladding (w)

$\lambda p := 0.35 :$
$\lambda c := 0.04 :$
$\lambda i := 0.0645 :$
$\lambda b := 0.044 :$
$\lambda w := 0.26 :$

$ep := 0.003 :$
$ec := 0.025 :$
$ei := 0.4 :$
$eb := 0.06 :$
$ew := 0.35 :$

$Ri := 0.13 :$
$Ru := 0.04 :$

$$Rp := \frac{ep}{\lambda p} = 0.008571428571$$

$$Rc := \frac{ec}{\lambda c} = 0.6250000000$$

$$Riso := \frac{ei}{\lambda i} = 6.201550388$$

$$Rb := \frac{eb}{\lambda b} = 1.363636364$$

$$Rw := \frac{ew}{\lambda w} = 1.346153846$$

$$U := \frac{1}{Ri + Rp + Rc + Riso + Rb + Rw + Ru} = 0.06334541419$$

U-value calculated: **0.06** $\boldsymbol{W/m^2K}$
U-value tested from EcoCocon: **0.12** $\boldsymbol{W/m^2K}$