OUROBOROS

The symbiotic relationship between kid and elder care.

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MSc04 - ARCHITECTURE AND DESIGN - GROUP 19 - 2020 - AALBORG UNIVERSITY

Project Title: *OUROBOROS: The symbiotic relationship between kid and elder care.*

Semester: *MSc04 Master Thesis 2020*
Group: *19*
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Project Period: *26. 09. 2020 - 22. 12. 2020*
Department: *Architecture and Design*
Number of Pages: 200
Number of Appendices: 10
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READING GUIDE

The booklet consists of seven chapters each presenting and discussing the different parts project and process. The appendices follow and are also provided in separate files. These include the full analyses and calculations and provide additional documentation than what is provided in the booklet. The references and quotes are done according to the Harvard method and the reference list, as well as the illustration list, are provided by the end of the book.

ABSTRACT

This project revolves around the research and design of a shared kindergarten and nursing home facility. It sets out to investigate the possibility and benefits of joining these facilities into one. The project aims to explore how architecture changes in this new paradigm. It explores the symbiotic relationship which these two facilities could share, as well as the benefits in the mental development of children and the decreasing of loneliness of elders. Additionally, the project achieves the design through design for disassembly and circular thinking. The project seeks to illuminate a method dealing with social circular sustainability, which seeks to achieve a holistic approach to marrying the environmental and social circular sustainability.

Ill. 1. Photo of "Spritten" constructionsite by Sørensen, C. E.

MOTIVATION

Depicted as a serpent or dragon eating its tail, the Ouroboros, from the Greek word for for tail devourer, is a symbol of eternity, renewal, and circularity of time. The symbol has been firstly observed in ancient Egypt in the tomb of Tutankhamen, around 1300 BC. It is later observed Greek, Gnostic, Norse, Hindu, Mesoamerican, and Roman cultures (Bekhrad 2017).

The threat of climate change looming over the present challenges people to adapt to meet this ever-growing peril. We must adopt sustainable behaviour or face the consequences. Although progress has been made in these efforts, many strategies have a singular focus instead of multidimensional approaches. Sustainability should be multifaceted and enrich the user experience. A trifold sustainable approach (economic, social, and environmental) should be adopted to ensure a holistic building culture. A much prominent way for the building industry to act towards this the call for sustainable building is by adopting the circular economy model and finding ways to apply it in our field. Circular thinking sparked the concept of Ouroboros architecture, a holistic approach where all resources are utilized and never discarded. A way to attempt to create a multifaceted approach to sustainability that would be enriching for the users. We identified an untapped resource within the current societal framework. Elderly people are an abundance of life experiences and knowledge, who are isolated in their last phase of life. Meanwhile, children are lacking in quality adult interaction. (Carlson and Agger, 2019) An intergenerational relationship could be a way to utilize this untapped resource and help develop the next generation.

This problem left us with some questions.

- What benefits are there within this intergenerational relationship?
- How does this alter the way we design these facilities?
- How does circular thinking alter the way we make architecture?

The project aims to create a methodology under which circular thinking can be applied in more aspects than technical, within architecture.

INTRODUCTION

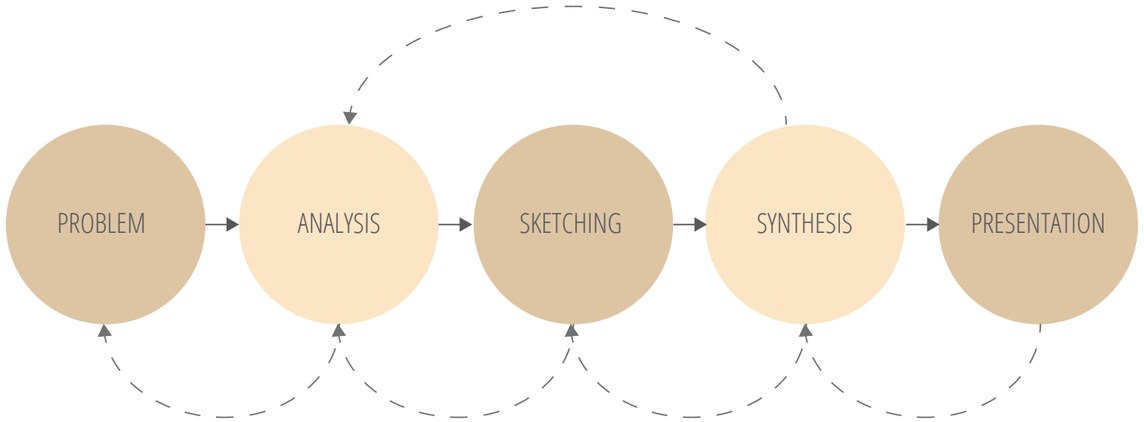
> *"In the coming decades, there will be many more older people in the United States at precisely the moment it is imperative that we do everything possible to nurture and develop the next generation. Why not match talent with need, tap experience for youth, connect supply with demand? Why not activate this solution hidden in plain sight?"* (Carstensen, Freedman and Larson, 2014 p. 28)

Denmark is known for its robust healthcare system, which offers support for the entirety of the population. However, recent Danish news stories show a trend of negligence within caretaking institutions, such as nursing homes and kindergartens. Kids appear to be getting very limited time of quality interaction with adults, of approximately 15 minutes per day, while elders seem to suffer from loneliness (Carlson and Agger, 2019). The main cause for this outcome is attributed to the lack of funding, and therefore time, within these facilities. The amount of time dedicated to the engagement of elders and the adult interaction with kids is dwindling. The problem stems from the optimization of resources within these facilities, and the workers cannot cut down on essential activities which makes the institutions run. Therefore, less time is dedicated to the engagement of elders and interacting with kids.

The predicament seems to only intensify with the growing population of older people (Ældresagen, 2019). Resulting in an increased amount of caretaking needed by a decreasing number of working adults. Likewise, kids are suffering from this development.

The tendencies described above show a pressing dilemma facing the caretaking systems of today. A solution may be found within the gap of these dilemmas. The elders aren't being utilized as the abundant resource that they are. Studies show a great benefit in younger people's mental development and non-cognitive skills when interacting with elderly people(Carstensen, Freedman and Larson, 2016). Likewise, the elderly gain socio-economical benefits and minimizes loneliness and depression.(Seo, 2006) A symbiotic relationship occurs in this paradigm. Therefore, it would be possible to realise those benefits in a joint facility, housing both a kindergarten and an elder centre.

Architecture can become a solution to these obstacles. The two typologies have a lot of common facilities and have engagement-problems with its occupants. We hypothesise that these typologies how complementary obstacles, which within a new form of typology, a joint facility, can create a symbiotic relationship which lessens the difficulties and improve the socioeconomics of the occupants. Likewise, within a traditional framework of designing such facilities, space can be reallocated from the common maintenance and support spaces into the living areas.
We hypothesize that a symbiotic relationship between a kindergarten and elder centre can be achieved. This facility would alleviate many of the problems facing the caretaking institutes of today. Likewise, a focus on sustainability is needed within the building sector. Focus will be given to the environmental and social sustainability of the building, as the goal is for the building to have a low impact for the health of the environment and the users while at the same time providing an architectural expression that enhances the local cultural identity and facilitates the culture and knowledge transfer between the users. We also expect that this joining of the two facilities will result economic savings and therefore this is to be investigated, however it is not the driving motive for the project.



Ill. 2. Ring Hansen, H. T. & Knudstrup, M.-A. (2005) The Integrated Design Process (IDP)

INTEGRATED DESIGN PROCESS

The project is aligned with the principles of the Integrated Design Process (IDP) (Ring Hansen et al., 2005). IDP is a holistic approach that includes the new findings and conclusions to the project and adjusts it accordingly.

IDP consists of five phases, where each one gives feedback to the previous and following ones. The first phase is the problem definition, where the initial idea is conceptualized and defined. The analysis phase follows, where relevant to the initial idea academic literature, theories and case studies are gathered and analyzed to provide informative content for the project, as well as site analyses take place in order to understand the context and its potential. The produced information from the analysis phase forms the vision and design parameters, and all the steps up to this point shape the program.

The next phase is sketching, which happens based on the program. Sketching can happen either by hand or through digital sketches. At this point, the most preferred design ideas are tested for energy efficiency, environmental footprint and other technical aspects to assess their potential to reach the desired performance, according to the project's goals. After the assessment, the project proceeds to the next phase, which is the synthesis of the chosen design to be accompanied with all the architectural and engineering details required to complete the project.

The final phase refers to the presentation of the project and it includes the finalization of the report and complete preparation of the material that is going to be used to present the final product. This can include physical models, posters, 3D models, slides, and any other possible mean to communicate the core qualities of the project.

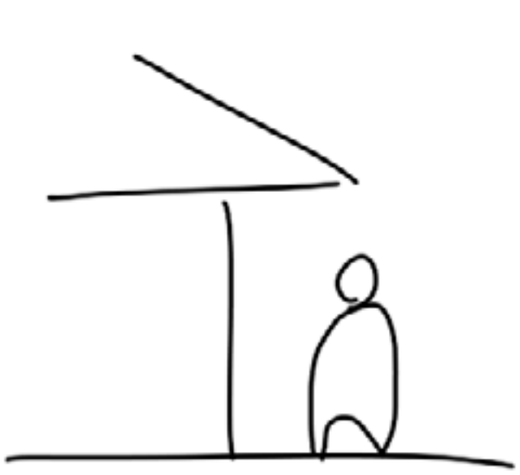
INITIAL PROBLEM

How does one create a circular building which facilitates a symbiotic relationship between childcare and eldercare? And what benefit can be created through an intergenerational facility? And does architecture change when designed based on the circular culture?

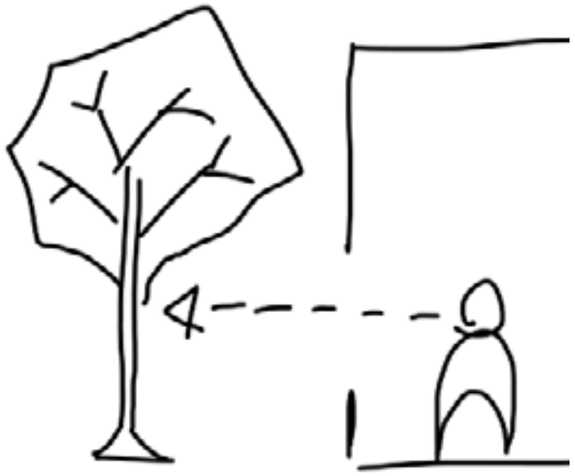
1

RESEARCH ON RELATIONSHIP BETWEEN BEHAVIOR AND SPACE

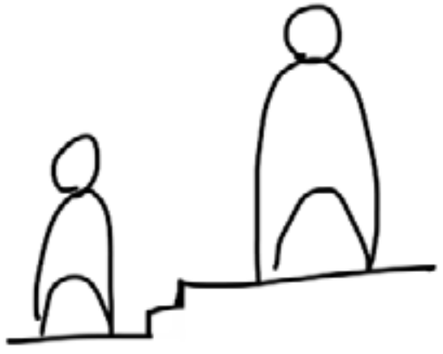
Intergenerational symbiosis
The users
Possibilities of active intergenerational interaction throughout the day
Intergenerational activities
Setting the stage
The living spaces
The Reggio Emillia approach
Holistic sensory experiences
Sub-conclusion



III. 3. Build in relevance to the human scale



III. 4. Spaces have visual access to nature as this calms the users



III. 5. Define boundaries

INTERGENERATIONAL SYMBIOSIS

The time that people spend in retirement is increasing as it is documented that life expectancy has risen by 32 years since 1900, while the age of retirement remains almost the same since 1916, approximately at the age of 65 years old (Laura Carstensen, Marc Freedman, 2016). The current model of going from full-time work to full-time leisure without including a transition period appears to create feelings of isolation and depression to older adults, while at the same time decreases their willingness for physical activity.

According to Laura L. Carstensen, Stanford psychologist, the number of older people is *"the only natural resource that's actually growing" (Laura Carstensen, 2016, page 17)*. The elders are a knowledge resourse of life experiences, as they have faced multiple complex social and professional issues and have developed strategies and solutions to overcome such challenges. Additionally, they are at a phase in their life where they have come to the realization of their mortality, which allows them to develop a sense of prioritization, meaning they know what is important and what should be let go, as well as the sense of emotional stability and forgiveness. The fact that they have the motivation to give back to the society is also highly important, as older people feel intensively that they want to create their own legacy. Lastly, people who reach the age of retirement often are highly skilled on a professional level, and that aspect makes them ideal to become mentors. While having so much to give, older adults also require mental and physical stimuli, as it is by now known that the human brain keeps on flourishing in all life stages, including the elderly stage.

On the other side, the kids benefit from interacting with adults other than their parents in several ways. Firstly, this interaction helps them develop both their cognitive and non-cognitive skills. This means that they get a head start in abilities such as learning how to read and write, as well as become more social and acquire self-control while getting motivated to form a sense of purpose. Additionally, studies have shown that the more love and attention the kids get, the more balanced their level of the hormone of cortisol is. This hormone controls feelings such as stress and anxiety, which, when unbalanced, can have a serious negative impact on the thriving of a child on its way to adulthood.

It is by now apparent that both of these user groups benefit from interacting with each other. The kids learn both practical and emotional skills while developing a sense of self-worth, while the older adults get stimulated on a mental level and remain physically active, which contributes to their well-being, while they get a feeling of social belonging and value. Most commonly, though, the care programs rely on age segregation, which can lead to older adults to develop the feeling of isolation. This calls for the planners to come up with solutions that acknowledge the interdependence between generations and promote frequent intergenerational interaction.

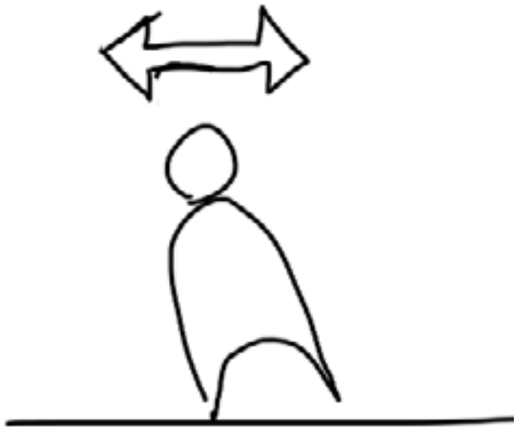
BUILT ENVIRONMENT

There are some clear indications that the design of an environment that facilitates the young alongside with the old can have an impact on the development of their cognitive and social skills (Seo, 2006). Therefore, regarding the facilitation of these users, the design has to focus on characteristics such as the size of the activities areas, the character of the building, the visual and noise stimulation, the feeling of safety, the sense of orientation and the lighting.

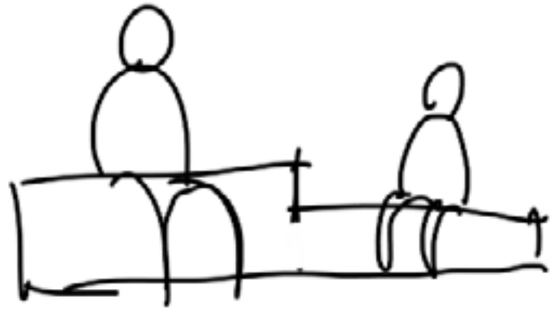
The number of elders living in a nursery home and therefore the size of it appears to be connected with the stress levels of both the personnel and the relatives of the elders (Annerstedt, 1997). Additionally, avoiding the institutional design and instead creating a home-like feeling decreases the stress of the elders living in the unit (Annerstedt, 1994). This leads us to the conclusion that creating a non-monolithic building that provides the home experience benefits all.

The visual and noise stimulation have to be regulated according to the use of a room. The semi-open plan appears to be ideal for common activity rooms, as it provides sufficient visual stimulation for both the kids and the elders to feel secure yet engaged enough to interact (Seo, 2006). Also, visual provision to nature seems to have a calming effect, therefore it is important for it to be achieved through all indoor areas, at an appropriate to the use and required privacy level. The level of privacy also affects the noise that should be allowed to penetrate from one room to another, as the facility hosts both semi-public and private activities. For this reason, additional acoustic insulation should be installed between rooms that accommodate activities of different privacy level.

The factor of safety is of high importance for the ease of these users. The personnel should be able to guard both the kids and the elders



Ill. 6. Ease of navigation through the building



Ill. 7. The common activity rooms include furnishings on the scale of both the kids and the elders

at ease. The semi-open plan for the common activity rooms that is mentioned above will help the personnel in guarding the rest of the users, but additionally there should be a careful design of the outdoor areas. The low vegetation will be preferred over the high, so that it becomes hard for either kids or elders to be off-guarding; instead, to facilitate the kids' need for outdoor play, there can be designed a specific private outdoor area.

Orientation can be a troublesome topic for both the kids and the elders. To allow these user groups for easy navigation within the building, the design will apply a version of visual coding for each area according to use. These visual signs can be either different colors on the walls of each room according to use or some artwork to allow the users to remember where they are inside the building at a given time.

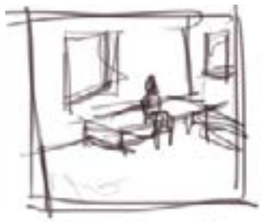
There is contradicting information regarding the type or amount of lighting that would be most beneficial to these users, as, although plentiful of light in the common activity areas can be stimulating, it can also lead to fatigue (Seo, 2006). For this reason, it is decided that both natural and mechanical lighting has to be able to be adaptable, regarding the needs of the users. The natural daylight can be easily regulated through installing blinds on the openings.

The density of a room appears to be highly connected to the development of the social, language and cognitive skills of the kids. Experiments have shown that kids facilitated in low-density daycare centers tend to interact verbally more with adults, while they also present fewer behavioral issues. On the contrary, high-density rooms seem to cause aggressiveness, hyper action and anxiety to kids, as well as antisocial behavior. Therefore, it is a strong link between room density and the impact it can have on the kids, regarding the development of their social and learning skills. For this reason, it is recommended that each room dedicated to learning activities should have at least 3 sq. m. available per child and the groups of kids and adults should be of 14-20 people in total.

The organization of the rooms seems to directly affect the kids, as spatially organized rooms enhance the creativity and focus of the kids, compared to randomly organized rooms. Therefore, a spatial plan is determined for the design of the activity rooms, meaning that these rooms should be efficiently organized to provide appropriate space for the activities yet allow the free movement flow within the area.

Finally, the common activity rooms will be equipped with furnishing appropriate to the size of both the elders and the kids, as this will create a feeling of inclusion to both the user groups.

THE USERS



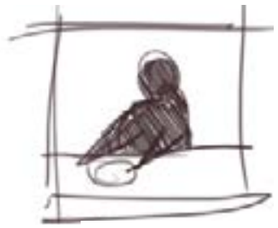
The elder wakes up

Has breakfast while greeting the kids

Has visitors

Naps

Has quality time with the kids



Has dinner

Has leisure time with other elders

Sleeps

Ill. 8. Storyboard for elder

USER PROFILE: ELDER

The elder who attends a nursing home within an intergenerational facility is a person that has retired from their job and wishes to live under such a facility for either physical or psychological reasons or both. Physical reasons refer to the physical challenges that humans face as growing up, which can harden the process for one to take care of themself and complete daily tasks. This natural state of the human body at an age above 65 years old can, moreover, create psychological challenges as well. The sense of helplessness often develops in the elders, while additionally, the feeling of loneliness appears as someone who is retired can suddenly find one self excluded from the society, as they can no longer participate through their past role. Therefore, by residing into an intergenerational facility, an elder expects to have help provided to them in order to complete their everyday tasks, such as showering, while they additionally expect to find a friendly environment that will allow them to feel included and give them the opportunity to socialize on a daily basis. Moreover, the elders expect to regain their sense of value as they interact with the younger generation, and therefore, redefine themselves through it.

Users of similar facilities suggest that they like a lively environment and wish to be able to customize their units, while additionally, they want the environment to include comfy guest rooms, in order to become more inviting to the elders' relatives and friends. The liveliness of their space can also be increased by providing sufficient daylight and fresh air. Furthermore, the elders seek an environment that enables them to socialize, however, they still value privacy in some activities, such as getting a health check-up from a nurse. Their often reduced motor skills require for a facility to allow for easy navigation and access to all interior areas, as well as to nature.

Sources: 1. Health Services Advisory Group I, 2015, "A Resident Perspective on Life in a Nursing Home"
2. CNA Insider, 2016, "Life In A Nursing Home - Talking Point"

A DAY IN THE LIFE OF AN ELDER LIVING IN AN INTERGENERATIONAL FACILITY

1. The elder wakes up and showers

2. Has breakfast and greets the kids as they arrive

3. Exercises

4. Gets physical and psychological check-up from nurse

5. Eats lunch

6. Naps

7. Participates in intergenerational activities with the kids. This could include reading to them, drawing, garderning together etc.)

8. Eats dinner

9. Participates in social activities with the other elders. This could include board or card games, dancing, karaoke sessions etc. The staff could be part of this, as it is common for them to develop a kind of friendship with the elders.

10. Sleeps

Kid arrives

Class starts

Plays in nature

Eats with other kids and elders

Spends quality time with elders

Leaves

Ill. 9. Storyboard for kid

USER PROFILE: KID

The kid ages 3-6 years old and therefore is absorbant to stimuli and curious about the world that surrounds it. This is the ideal time for it to develop knowledge that will broaden its curiosity and understanding of nature and the world while developing its social skills. For the kid, it is expected to learn basic knowledge, such as reading and understanding basic arithmetic, before leaving kindergarten. Additionally, though, the attendance to a kindergarten within an intergenerational facility and the regular, periodic and structured, interaction with this other generation is expected to allow the kid to gain additional knowledge, such as getting familiar with the concept of playing a musical instrument, painting, or gardening. It is equally important for the kid that all this process of learning happens through social interaction. The kid is expected to know how to interact with both other kids its age but moreover, it is expected to learn about feeling comfortable while interacting with people of older age, developing a sense of equality between people of different age groups and growing an understanding for the strengths and weaknesses of each of them.

The kids should be encouraged to participate in group activities while in the facility, as they appear to be useful for them, while the kids enjoy them. Additionally, they seem to like laying around in the classroom, therefore carpets and cushions should be added, however, it is also mandatory for the classrooms to be equipped with tables and chairs on the scale of the kids, to ensure correct body posture while doing specific activities, such as exercises that include writing or drawing. Moreover, kids love running and climbing, therefore there should be indoor areas designated for such purposes, as well as direct access to nature, where they can perform such activities. Finally, the decoration of the area with the drawings and crafts of the kids can enhance the feeling of a lively environment.

Source: Turning Point School, 2015, "A Day In The Life of Kindergarten"

A DAY IN THE LIFE OF A KID IN AN INTERGENERATIONAL FACILITY

1. The parent brings the kid to the facility, the kid greets the other kids, elders, and staff, and possibly plays with the other kids for a short time

2. The class starts, the kids sit together and the teacher teaches them about letters, numbers, colors, reading the calendar etc.

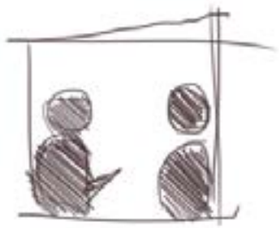
3. The kids sit in group tables and do reading/vocabulary/arithmetic exercises with the help of the teacher. The exercises could be in a form of a game

4. Outdoors time. This could mean time in the playground or a trip to a nearby park of other nearby facility, where the kids can be introduced to nearby activities of the town

5. Lunch

6. Intergenerational activity time. This could refer to singing or dancing together, reading or gardening together, storytelling, drawing etc.

7. The parents come to pick up the kids. The kids say goodbye to everyone



Nurse arrives in facility

Checks the elders

Assists the elders that need help

Eats while keeping an eye on the elders

Has private session to perform health check-ups to the elders

Makes a final round to see if their assistance is needed

Prepares daily reports for the condition of each resident

Ill. 10. Storyboard for nurse

USER PROFILE: NURSE

The nurse is a professional with a multidisciplinary role in the facility. He/she is responsible for running health check-ups to the elders, taking care of the wounds of both the elders and the kids, and examining the psychological condition of the elders on a regular basis while also keeping track of unhealthy psychological behavior of the kids. Additionally, they are responsible for documenting the state of each user and informing their families and doctors accordingly. Moreover, they assist the elders when they have difficulties completing daily tasks. This job, however demanding, can also be very rewarding, as the nurses appear to draw happiness from the happiness of the people they curate, and state that this sort of daily interaction can lead to a friendship that is valuable for the elders, the kids, and the nurses. They find their job interesting as they also learn from the stories of the elders. They sympathize with the elders and find that spending time with them, aside from running health tests or assisting them, brings joy to them and the elders.

The nurses often feel stressed and overworked because of the workload, therefore they suggest that more than one nurse should be working on each shift. Additionally, they wish to have easy access from their office to the medicine storage and medical equipment. There has to be a separate space for treating the kids and the elders, another space for doing documentation work, and a space for storing their private belongings, while privacy is required for all these spaces.

Source: Heart H., 2013, "A Day in the Life of an LTC Nurse"

A DAY IN THE LIFE OF A NURSE IN AN INTERGENERATIONAL FACILITY

1. The nurse arrives to the facility and receives the reports concerning the status of the residents from the nurse of the previous shift

2. Walks around the area to check the residents firsthad, for the case that reports are not updated

3. Performs health check ups to the residents with specific health issues, such as diabetes, and gives them the appropriate medicine, according to their schedule

4. Helps the residents in tasks such as showering and eating

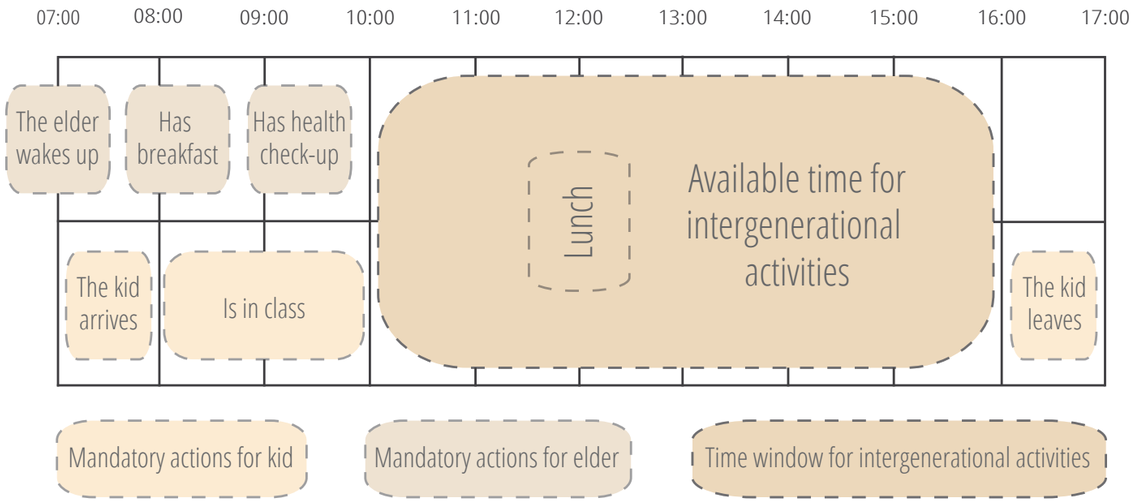
5. Eats at the same time with the residents in order to be able to keep an eye for accidents, so that he/she can help when someone is choking for example

6. Performs skin and physiology tests to the residents individually. Moreover checks their mental condition

7. Prepares documentation and informs the appropriate doctor and the family of a resident when this is needed

8. Makes a final round to make sure that all residents are safely doing their scheduled activities

9. Prepares report for the nurse of the next shift and leaves



Ill. 11. Time window for intergenerational interaction

POSSIBILITIES FOR ACTIVE INTERGENERATIONAL INTERACTION THROUGHOUT THE DAY

The analysis of the daily routine of the main users shows that for them to be available for intergenerational activities, some actions need to take place beforehand. The elder user needs to follow some morning, private activities, such as take a shower and get a health check-up, before they can start participating in group activities. On the other hand, the kid needs to be present in the facility and attend the class for a minimum of a couple of hours, which is a group activity but does not involve the elders, as the ongoing activities would pose no interest to them, while at the same time, it is important for kids to socialize with other kids their age as well. In between each of these activities, more ephemeral occasions appropriate for social interaction may occur, which also can be facilitated through design, however the structured group activities that can be organized by the team target the time where the majority of the users are available, and that is at earliest after 10:00.

By 10:00, it is expected that a time window of five to seven hours would be open, depending on the schedule of each parent and therefore the time they are able to pick up the kids. The fixed activity of having lunch between 11:30-12:30 is a necessity for all users, and therefore it can be considered as a given that it provides an opportunity for kids and elders to participate and interact. Therefore, the activities that can be structured by the team for the building users can take place between 10:00 to 11:30 and 12:30 to 15:00-17:00. Of course, there are still activities that concern only one of the user groups that have to take place within this time window, such as the fact that the elder may have visitors or may wish to work out by themselves or take a nap, while the kid might participate in a group trip to a nearby educational or recreational activity, or even stay within the facility and follow an activity that concerns the kids, but does not take place within the classroom. The difference, though, with such activities, is that they may not be happening daily, their time is not fixed, and most importantly, they are not mandatory for the users to be ready to participate in intergenerational activities.
Understanding the available time slots and the activities that need to precede for all users to be available for the intergenerational activities, alongside with the analysis of the daily routine of each user group individually and the nature of the other activities that they need within their day to happen, is expected to help the team in designing intergenerational activities that facilitate the needs that have been observed, such as quality social interaction, mental and physical stimulation, recreational time, direct contact to the nature and so on.

INTERGENERATIONAL ACTIVITIES

The common activities aim to keep both user groups stimulated in order to be valuable. Therefore, there can be defined some common goals that benefit both user groups, each in a different way, that can form the choice of what activities should be implemented into the building. It is desired that all participants can develop their cognitive, social and emotional, and physical abilities (Martins, T. et al., 2019). For the kids, the goal is to encourage them to develop their ability to express themselves, as well as to learn how to cooperate and show empathy, and support their sensory development. The elders are expected to get encouraged to sharpen their memory, to develop the feeling of nurture, self-confidence, and communication, as well as maintain their motor abilities. Finally, this interaction is expected to boost the positiveness in both user groups and enhance the cultural coherence between the different age groups.

The systemic periodic frequency of the intergenerational sessions is highly important for the kids to relax and feel trust towards the elders, which do not belong to their family. Additionally, it is important that such programs are ongoing for a minimum of one year, for the same reason (Generations United, 2019). From the perspective of the elders, in order for them to remain stimulated and at the same time feel confident, it is important that they are free to practice multiple of their skills that they already acquire at a high level, and for this reason, there has to be some flexibility on the layout of the building and some variety on the available equipment. This availability of choice is also expected to benefit the kids, as it provides for them a variety of abilities to develop.

The activities can either be in pairs or in groups of multiple participants. However, for the sake of the mental stimulation of the elders, it is encouraged that they are formed in groups of one elder per 7-10 kids (Martins, T. et al., 2019). Ouroboros strives to achieve high intergenerational contact, which, through the review of studies for similar existing facilities, appears to be equal to five to nine hours per week (Jarrott S., et al., 2008). Another characteristic to take into consideration is the age of the kids, which, in this case, are 3-6 years old. The activities can be defined as common for all and optional, according to the availability from the side of the elders and the demands of the kids.

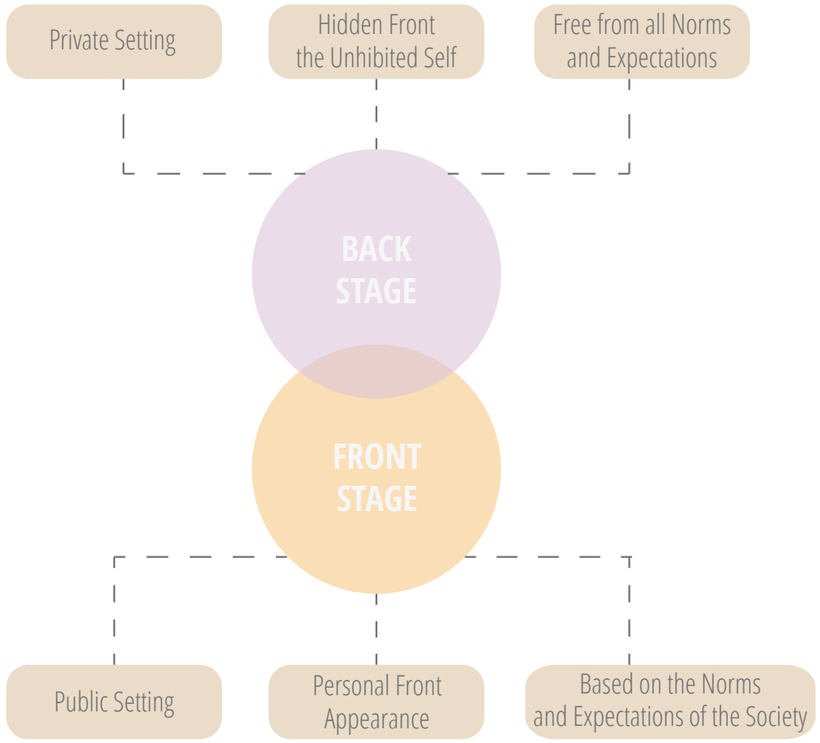
READING
This is a type of activity that is equally useful to all the kids and can happen on either pairs or in groups. The kids are in the right age to learn reading, while they also develop their sense of creativity and storytelling. The elders get a sense of purpose which is much needed at the times of retirement.

HEALTH
The health-related activities can either involve an actual physical, cooperative workout, or be provided in a form of an educational program about basic health knowledge, such as body functions, or about health issues related to one of the user groups, such as diabetes.

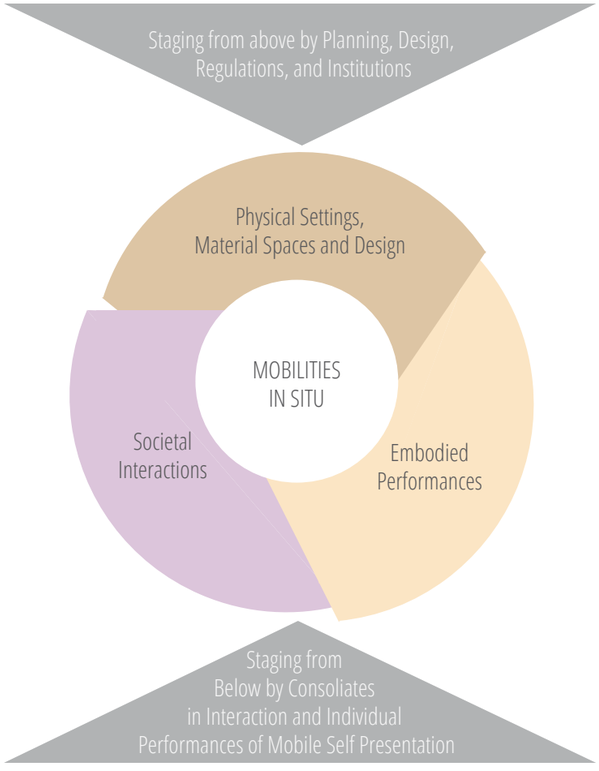
CULTURAL EXCHANGE
One of the rarest and most valuable assets of interacting with the elderly is the fact that the kids have the chance to listen to first-person stories about the past of the elders that shaped their future and the current reality. The kids learn not only storytelling but also, through sympathy, learn important life lessons from the elders. Meanwhile, the elders get to use their memory and feel confident about themselves. Through such activities, the always existing cultural gap between different age groups is expected to be reduced, regarding communication.

ART
Most people have an artistic side; however, this may be expressed in a different way for each person, therefore, for this activity to take place, it is important that space can be adapted to the needs, and that several types of equipment are available. There are elders who can teach the art of painting to the kids, while there are others who knit, and others who know how to play an instrument. The list of the art-related activities is never-ending, though the key aspect to keep from this realization is that the space that facilitates such activities should not be highly utilized to match one activity, but instead there should be provided openness and easy access to storage of art equipment, in order to facilitate as many of them in variation as possible. The benefits are multiple for all participants, as both the creativity and self-expression are encouraged, while the kids learn new skills that they are genuinely interested in and the elders get to exercise and share the knowledge that is of high value to them, as well as spend time on an activity that makes them feel confident.

GARDENING
The contact with nature is known for demonstrating therapeutic benefits for the people, regarding their mental state. At the same time, it can encourage the user groups to cooperate and develop a sense of nurture while educating both the kids and the elders about flora, by providing them with a space to grow plants. This activity can increase the understanding of all users towards nature and help them develop a sense of connection to it.



Ill. 12. Interpretation of Goffman's theory , Source: Goffman, 1956, The presentation of Self in Everyday Life



Ill. 13. The staging mobilities framework, Source: Jensen, (2013), Staging Mobilities, p. 6

SETTING THE STAGE

The project strives to explore the coexistence of two user groups with different privacy needs, as kids may need to be supervised at all times, even when the supervision might be discreet, however the elders, who enjoy the interaction with the kids, may require to maintain a sense of privacy during certain activities, such as when walking from their room to the nurse's office and back. In order to understand and include these needs in the project, we look at the work of the sociologist Ervin Goffman and his book The presentation of Self in Everyday Life (Goffman E., 1956), where he analyzes the way that us humans present ourselves according to the level of privacy in an area. Goffman suggests that any person has a front and a back stage, or the personal front appearance and the hidden front of the self. The front appearance requires a public setting to be enabled which is based on the norms and expectations of the society, while the hidden self behavior takes place on a private setting and, being free from the societal constrains, it is shaped by the person itself. By the term "setting", Goffman refers to all the elements that compose a scenery, including the layout, the furniture and decoration of an environment, which are required for a person to get into its front stage behavior, which behavior will stop as the person exits the particular setting.

In his book Staging Mobilities (Jensen, O., B., 2013), the researcher on sociology and urban planning Ole B. Jensen attempts to translate Goffman's theory into an urban planning context in order to explore the behavior of the users under different privacy zones. It is explained that the setting requires the involvement of both the designer and the user, where the designer has to consider the social, spatial, and temporal aspects of an area and provide an environment aligned with these needs, while the user, who shapes these aspects, is required to liven up the stage and "perform" accordingly. Furthermore, it is clarified that a social interaction can take place in spaces with different privacy levels, with the difference being in the nature of the interaction itself. Specifically, Jensen explains that, in certain areas, the interactions that can take place can be described as "gatherings", as they have an informal and ephemeral character, while other areas can host "social occasions" as they are designed for formal interaction and can therefore be hosting interactions continuously.

SOCIAL INTERACTION IN THE FACILITY

This analysis has helped in reaching to the forthcoming conclusions. Firstly, it is understood that although the project aims to join the everyday life of the two user groups, this should not compromise the need of the elders to maintain privacy when feeling weak and being in need for medical help. Therefore, there should be a distinction between the public, private, and semi-private zones that can allow for the elders and the kids to show on the stage when they feel able to perform their front selves. Secondly, it can be realized that the need for privacy does not limit the social interaction areas; on the contrary, it only informs the design in creating areas for several types of social interaction, those being quick and informal, and those being long-lasting and formal. Lastly, through this analysis it is highlighted that our role as architects and engineers has a direct effect on the social behavior and interaction and therefore our designs should reflect our study of the habits, desires, and needs of the users at each time.

THE LIVING SPACES

Jan Gehl is an architect and urban planner responsible for the renewed movement for the betterment of urban environments and the nurturing of life in between houses. In his seminal work Life Between Buildings: Using Public Spaces, he discusses and explains why some urban spaces are used while others are left forgotten. He clarifies that urban spaces have to adopt an anthropocentric view. His goal is to further the one-on-one human interaction in the urban areas. However, many of his observations and conclusions could be applied to other constellations of human interactions. If viewed through a macro lens, the urban social environments Gehl talks about are just people navigating spaces in which that do not know one another. Of course, people do have close relations with some people they meet on the street, but the large majority of people one navigates around in urban situations are unknown. Jan Gehl describes the level of intensity of these different relationships as such;

- Close friendships
- Friends
- Acquaintances
- Change contacts
- Passive contacts

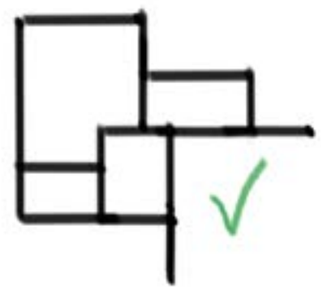
These five levels indicate ways that people interact with one another in these social situations. Within a joint facility of a kindergarten and nursing home one needs to design to facilitate all levels of social intensity. For the four most intense levels one needs to make places that facilitate the meetings of these people, however, for passive contact a certain level of visual connection between the two groups needs to be available at all times. This would help to nourish the social connection between the two groups. This further support by Gehl's work wherein he states that people are inspired by seeing others interacting. The visual activities we perceive are what we are drawn to. Gehl references a study by a group from The School of Architecture at the Royal Danish Academy of Fine Arts, which states the place in which most people stopped by and looked was a construction site. Although that number dropped dramatically when none activity was on the site. This shows that people are drawn visually to the places with the most activity. Children are likewise seen to want to play where most activity occurs. The children seem to want passive contact while still playing alone, like children playing in the living room while the other family members do their tasks. Additionally, unlike the other forms of visual stimuli in passive activities, being present in a space, forces one's participation in the social situation, no matter how small. Gehl likewise states that the reward for passively hearing and seeing human activity is more rewarding than other activities the city provides.

THE REGGIO EMILIA APPROACH

The need of parents to know that their kids are safe and secure often leads for the design of kindergarten environments to be segregated and sterile, thus dictating the nature of the activities to be undertaken in each area for the kids and allowing for low creativity from the side of the architect (Dudek, 2015). The Reggio Emilia approach proposes some guidelines to reverse this, without compromising the safety of the kids. Reggio Emilia is a city of Italy, which, after the World War II, revolutionized the design of the public educational environments, under the recommendations of the children educator and educational philosopher Loris Malaguzzi (reggiochildren.it, n.d.). From then and on, the approach has been embraced and applied in more than 145 countries, in educational institutes of all age groups.

The Reggio Emilia approach has developed its guidelines for infant-toddler centers and preschools based on their manifest called 100 languages (reggiochildren.it, n.d.). 100 languages is a poem written by Louis Malaguzzi and, in short, it describes how every kid is naturally curious to explore its surroundings and capable to create and enrich its own learning experiences, given the environment to do so, but the problem is that often the adults try to dictate what experiences the kids should have and how they should perceive them. The poem ends by indicating that the kid knows that there is more to experience. One of the most obvious meanings of the poem is that the kid can flourish, if only it is given a great pedagogical environment.

But what makes a great pedagogical environment? According to the Reggio Emilia approach, when it comes to communicating with children of preschool age, it is important to design according to what enables the human senses. The colors, material textures, lighting, and indoor environment, should all synergize to encourage the kids to explore, interact, and learn through the process (Dudek, 2015). Additionally, there are specific recommendations regarding the design that can facilitate this pedagogical experience. Firstly, it is suggested that, instead of following the standard layout of the main class, quiet room, wet room, cloakroom, and so on, space should be divided in bigger and smaller niches that communicate with each other and allow for the kids to decide how to use, and ideally, transform them according to their preferences. Following, a major element in the Reggio Emilia approach is the piazza, a, possibly central, common area, where the kids can freely interact and develop their social character and skills. Moreover, to promote democracy and break the top-down hierarchy that gets created by the co-existence of adults and kids in the same environment, it is suggested that the accessibility of the kids to most building areas is designed to allow for exploring activities. Finally, the environment itself should be designed concerning the kids' scale, whether this concerns the building layout or the furniture and equipment for activities.



HOLISTIC SENSORY EXPERIENCES

The work of architect and former professor of architecture Juhani Pallasmaa within architectural sensory understanding cannot be underestimated. His book the Eyes of the Skin (J., Pallasmaa, 2012) reveals a large biased within today's discourse and culture surrounding architecture towards the visual. The way we examine architecture's quality is firstly a visual image and secondly, the wellbeing of its occupants. We tend towards the ocular, although it is considered the most distant of all the senses. The other senses are associated with the self while vision is associated with what is distant. The experiences of architecture are multisensory. Architecture is defined in relation to the self, however, the ocular hegemony eliminates the self from the picture. Pallasmaa describes the experiences and memory are deeply linked with the other senses. The intimate senses, taste, smell, hearing, kinesthetics, and touch, are the ones that define our place while vision eludes to what surrounds us.

When focusing on the ocular experiences the complete multisensory experience is dulled. This ocular bias might be strengthened by the increased digital workspace architects find themselves in today. Great strides have been made to refabricate the visual in a digital environment, however, the other senses are lacking behind in this regard. This creates a dichotomy between the perceived building and the final built result. How ought architects act to combat this development? Firstly, one should be conscious of the bias, and try to evaluate architecture on a tactile level. One must seek to increase knowledge of the tactile and acoustic qualities of the building and know that the visual quality of a building is not the alpha omega of the project.

RESEARCH ON RELATIONSHIP BETWEEN BEHAVIOR AND SPACE: SUB-CONCLUSION

According to the examined research and theories, the integration of these two user groups should offer benefits to both the physical and mental state of all. To increase the benefits, the building has to allow for as many possibilities as possible for the users to interact, through both structured and unstructured activities, without compromising the more private activities that any of the user groups is required to participate in. Different levels of integration between the user groups have to be examined to determine the ideal scenario that balances intergenerational interaction with required privacy.

It is clear that both kids and elders should prefer a "warm" home-like experience in order to feel comfortable and engage with the other users the most. This can be achieved by building low and dense, like a residential neighborhood, while choosing materials that are mostly used in residencies instead of institutions. The visual contact, and ideally also the access, to the nature, regardless of one's position in the building, is much desired, as it appears to be having calming effects on all users.

A minimum of 3 m^2 per child is expected to improve the learning ability of the kids, while the intergenerational groups should consist of 14-20 people, in order to keep all participants stimulated without reaching to the point of frustration. The activities should not interfere with the ease of flow within the building.

The indoor area available for public activities should include both areas with specific qualities, according to the particular needs of some activities, and some open spaces, where kids may shape themselves. The explorative nature of the kids can be encouraged through designing niches that invite the kids to examine and shape. The areas designated for specific activities will require specific design decisions, such as space, equipment, furniture, and materials, to facilitate these needs. A semi-open plan for the public areas should allow the kids and elders to feel intimate enough to express themselves, while at the same time, it should allow the personnel to supervise all the other users discreetly. The area should ideally include a "plaza", which could operate as a core meeting point, where all users can freely interact and develop and/or redefine their own social behavior.

Some areas are more private than others, such as the way from the rooms of the elders to the nurse's office, and therefore these areas should include only ephemeral activities, for the sake of securing the need of dignity for the elders. The privacy level of each area should be communicated to the users through the design, which can be achieved by the difference of colors, material textures, art, etc. This stimulation of the senses for coding each room is expected to improve the ability of navigation for all users.

In public activities, the users should have visual access among themselves, as this keeps them socially stimulated at times where direct contact is not possible.

As kids enjoy climbing and running, such activities should be designed for indoors and outdoors. Kids also like laying down therefore carpets and cushions should be included in classrooms, however these cannot replace the chairs, as it is important for them to develop a correct body posture.

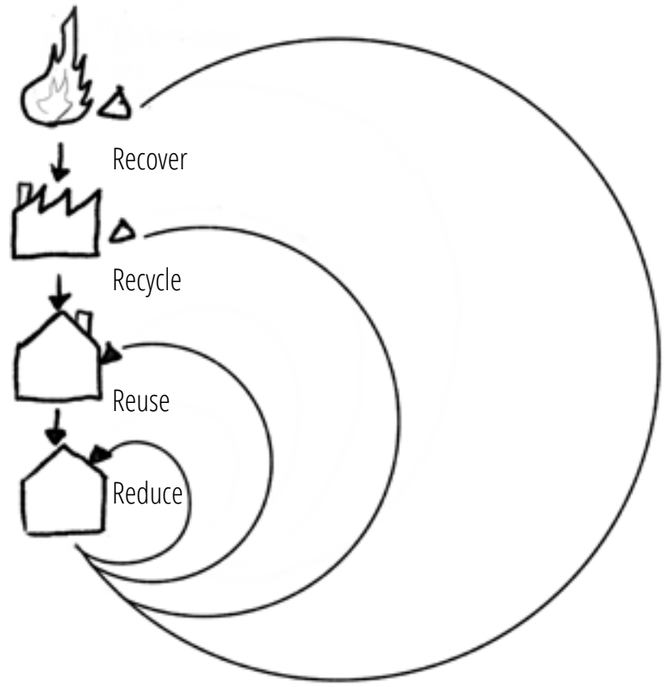
The personnel require privacy while working, but as some of their tasks include close contact to the other user groups, e.g. the nurse's office, the placement of such offices has to relate to the activities they support.

- *Visual contact to the nature.*
- *Access to the nature.*
- *Facilitate plentiful contact between user groups.*
- *Low-rise*
- *Spatial variation within plan*
- *Improved indoor comfort quality*
- *Communicate the scale of all users through design*
- *Design activity areas for small groups*
- *Spatial variation within plan to create niches*
- *Design rooms for specific activities*
- *Plentiful space for furniture placement option in elder units*
- *Acoustic design for use*
- *Central "plaza"*
- *Semi open plan for ease of supervision*
- *Privacy levels according to use*
- *Ease of navigation through the sensory experiences*
- *Resting areas orienting towards activity areas*
- *Design for the motion of kids*
- *Close connection between personnel and other users while maintaining privacy*

CIRCULARITY

Circular thinking
Energy and water
Indoor climate
Design for the future
Life cycle assessment in the built environment
DGNB for life cycle impact assessment
Inclusion of the benefits and loads via Design for Disassembly
Economic sustainablity within the design framework
Sub-conclusion

2



Ill. 14. Source: Kichherr, J. and Hekkert, M.P., 2017, Conceptualizing the circular economy: An analysis of 114 definitions. Utrecht.

CIRCULAR THINKING

The sources of the building materials that we use are finite. This fact becomes problematic as the current established economy worldwide is mainly linear. The term of the linear economy refers to the process that currently our products go through: from the extraction of the raw materials to the manufacture of the products to their use and disposal (Goddin et al., 2019). This type of economy depletes our raw material sources while creating an ever-growing amount of waste. Meanwhile, the mainstream manufacturing tactics, as well as the common tactics used in waste treatment worldwide, often are hazardous for the health of both the flora and the fauna of our ecosystem. Although the impact of the linear economic model is evaluated on an environmental level and is considered negative, the sort of entrapment that our society has fallen in lies to the fact that the growth of the economy currently depends on the constant input of new raw materials. However, it is apparent that this model is unsustainable and therefore there is the need for other economic models to be developed and applied.

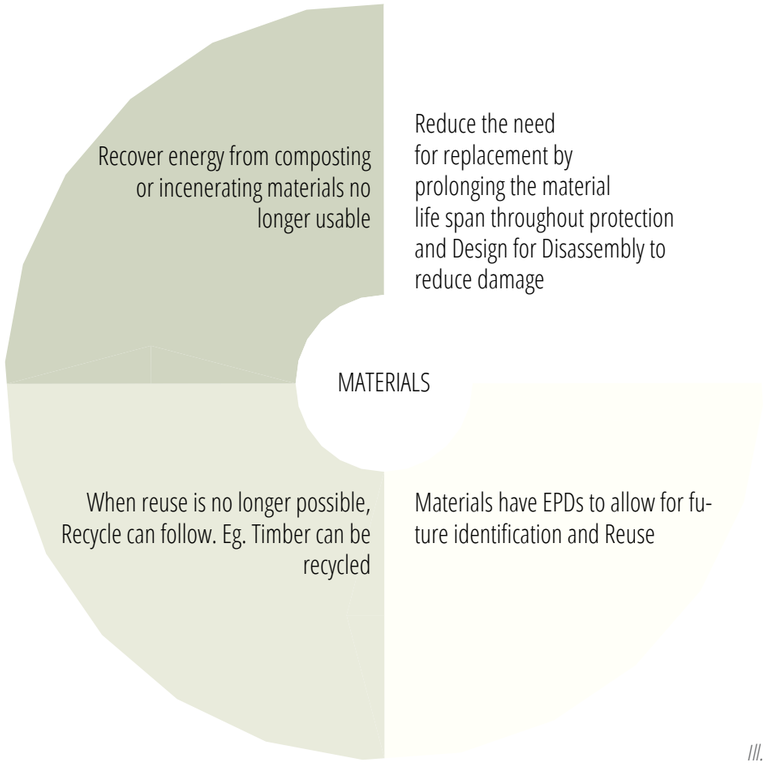
A promising solution to overcome this societal, environmental and economic form of pathogeny is the model of the circular economy. The circular economy strives to decouple the economic growth from the input of new, finite raw materials through putting all products in a constant closed-loop flow and developing principles to accompany this movement to ensure the integrity of our ecosystem (Goddin et al., 2019). To achieve this, the circular model recommends removing the waste phase from the life cycle of any material as well as the pollution included in it and focus on preserving the value of the materials through designing them for durability, reuse, remanufacturing and inevitably recycling, while promoting the use of renewable and regenerative natural resources. This model enables the products on maintaining their value and allows economies to mitigate risks related to material scarcity and price rises. The circular model is already used from several companies, however, for it to be fully effective, it is required to be adopted on a global level.

The model of circular economy certainly needs to be widely used from the construction sector, as our field appears to be responsible for the consumption of approximately 50% of the total available raw materials (Kubbinga et al., 2018), while the construction and operation of buildings consume about 36% of total final energy and produce 39% of the total energy and process-related carbon emissions (International Energy Agency and the United Nations Environment Programme, 2018). For the model of circular economy to be applied, there have been developed strategies, which emphasize that the used resources should be renewable and non-toxic and be used efficiently, while the focus should be given to prolonging the life span of any product and that the unavoidable waste can be handled as an energy and material resource as well. Further strategies to support the model include creating bigger product value through connecting products with services, designing while bearing in mind that the life span of a product should be connected to its purpose and therefore appropriate materials should be used according to this, tracking and optimizing the resources and getting the public sector collaborating with organizations to increase transparency and create products of joint value.

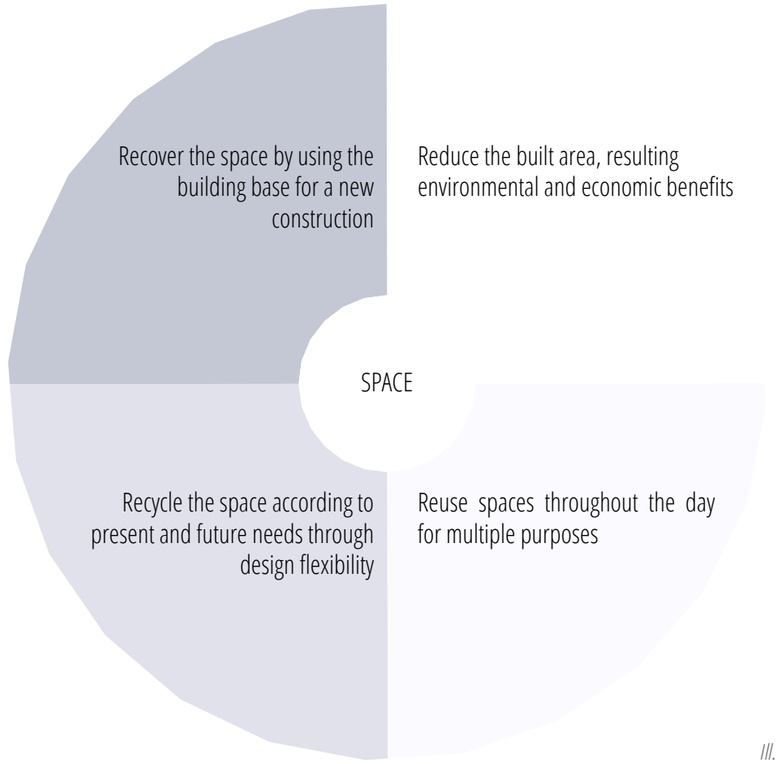
An adaptation of the circular economy model into the Ouroboros context is the following:

> *Ouroboros, as a fundamentally circular building, focuses on keeping its building components as well as its users into the biological circle, in an attempt to minimize the resource waste, on an environmental, economic, and societal level. It values the health of the environment; therefore, it relies on the use of non-depleting and non-polluting resources for its construction and operation. At the same time, it values the wellbeing of the users, and for this reason, it prioritizes to facilitate properly their needs as well as their probable wishes. All of the above are made in respect to the past and the lessons we can harness from the architects and engineers before us on providing quality buildings, and with respect to the future, ensuring that the Ouroboros can adapt to the future needs or even be transformed to facilitate totally new, unimaginable future needs, causing minimum environmental footprint.*

We are using the 4R framework (Kirchherr, Reike and Hekkert, 2017), which focuses on Reduce, Reuse, Recycle and Recover of the available sources, in order to analyze the process of the circulation of our materials, space and social interaction.



Ill. 15. Material Circulation Flow



Ill. 16. Spatial Circulation Flow

MATERIALS

REDUCE The aim is to reduce the need for replacement of the building materials and components by prolonging the life expectancy through design. This means that all components have to be well protected from wind, fire, moisture and rodents, and the components with a smaller life cycle should be further protected, for example windows can be protected with overhangs or exterior blinds. When, inevitably, a component requires replacement, our building strategy of Design for Disassembly will ensure that the replacement can happen without damaging any healthy components.

REUSE Having joints that allow for easy disassembly and reassembly of the building materials and components and using only products that are equipped with their Environmental Product Declaration (EPD) is expected to ease the process of reuse of the materials and components that are usable over the end of life of the building. Additionally, the building will be mainly of standard sized materials and customizing them will be avoided, to the extent that our architectural expression is not compromised, to allow for the products to have as big of a variety of potential future uses as possible.

RECYCLE The building materials the Ouroboros consists of, when no longer able to be directly reused, can be refurbished or remanufactured to fit into another project. For example, when a timber batten is partially damaged, the healthy part of it can still be used for the construction of a building or a piece of furniture. When that is not possible either, it can be recycled to become possibly a wood fiber board. It is important that the Ouroboros materials can remain inside the market loop for as many life cycles as possible, in order to avoid the depletion of resources and allow for the materials to maintain their full or partial value, or even increase it.

RECOVER It can be observed that, by circulating the materials into the market, they recover economic value. Inevitably, though, all of the Ouroboros materials will reach to the point that they can no longer be recycled into something usable. This is the time to incinerate them and recover energy that can be used to power other human activities.

SPATIAL

REDUCE The choice of combining these two user groups into one facility results reduction of the square meters required to build in order to host them, compared to building a separate facility for each. The reduction of built area equals to environmental benefits, as that translates to fewer materials needed and less construction time, as well as a smaller area to heat, therefore less operational energy demand. Additionally, these parameters result in economic savings, which benefit both the users of the building and the state, as it is common that it finances facilities such as both nursery homes and kindergartens in Denmark.

REUSE The kids are expected to use the building within specific hours of the day; however, the elders habituate there. For this reason, we propose that those unused rooms during the evening should be available for reuse by the elders and the local community. The design can easily adapt to these needs, by providing a storage place for furniture next to the kids' group units.

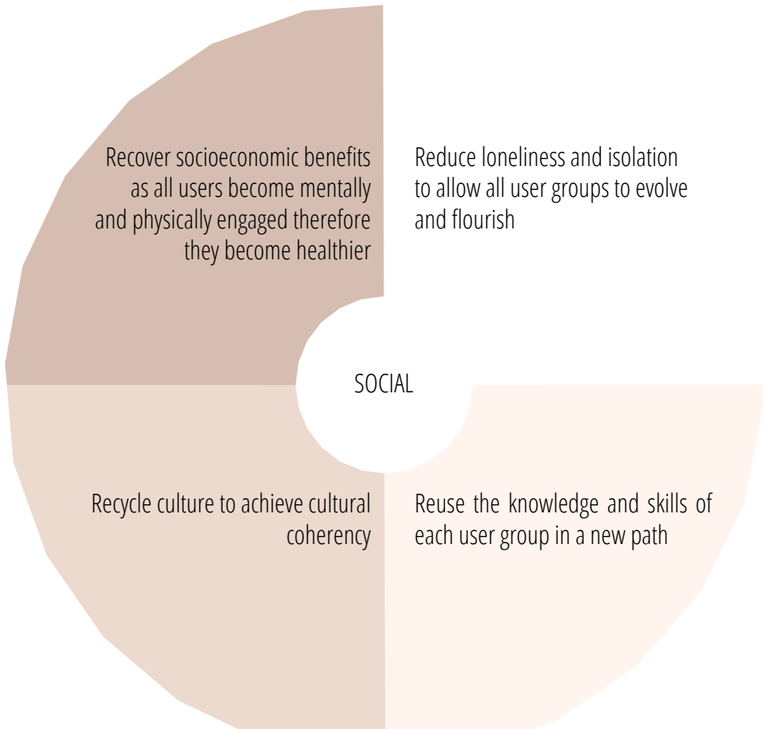
RECYCLE The spaces have to be flexible and adaptable to the needs of the users at a given time, both in the present and the future. It is important that the activity areas are flexible to host bigger or smaller events than the ones planned through this program. However, there needs to be given focus also to the trends of the near future. For example, it is known that, currently, the female personnel working in caregiving facilities is larger than the male, and therefore the current design has to take this under consideration and create changing rooms equivalent to these proportions. Nevertheless, as gender equality balances, it is expected that equal male and female personnel will work on such jobs (European Institute for Gender Equality, 2019), therefore the size of the changing rooms has to be able to adapt to these needs.

RECOVER

Ouroboros can create additional value to itself and the surrounding area through its architectural expression that aims to be inspired by the local architecture yet evolves it according to the current environmental, social and economic needs. Additionally, by the end of its life cycle, the base of the building is expected to be capable for use in future purposes, therefore a whole new building with a new purpose can be constructed on this base, recovering the space and eliminating the need for new foundation.

SOCIAL

REDUCE Ouroboros is an experiment that has the needs of the



Ill. 17. Social Circulation Flow

users on the main stage. In the chapter of Intergenerational Interaction, the reasons that such an experiment is worth attempting were explored. These reasons lie on observations of how both the kids and the elders flourish when they are given the chance to participate in the society. This is why Ouroboros aims to reduce the isolation of the elders and the child neglect through designing spaces that are welcoming these two user groups to interact.

REUSE Through the intergenerational interaction, Ouroboros aims to reuse the knowledge and skills that the elders have possessed throughout their lives, in a way that is pleasant to them, instead of letting them go to waste..

RECYCLE Culture is a living organism, and like any living organism, it needs to keep adapting into its given context and evolving in order to remain alive. Ouroboros aims to facilitate the sharing of culture in a bidirectional way, where elders can inculcate their traits to the young, but also the young can bring the elders closer to the future by expressing themselves in their own way instead of adapting to the habits of the older generation, as the behavioral context of their cooperation has to fit into the contemporary life. This way we can achieve cultural coherency.

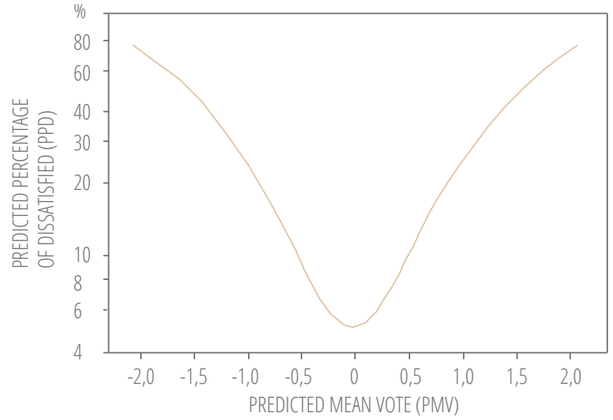
RECOVER As the users are the main concern, the target is to recover socioeconomic benefits by keeping the elders engaged both mentally and physically, on a reasonable pace, and encourage the kids to develop their cognitive and non-cognitive skills. This is expected to reduce the health issues of both sides and create happiness. Additionally, the personnel reduction achieved by joining the two facilities is expected to have economic benefits for both the state and the users.

ENERGY AND WATER

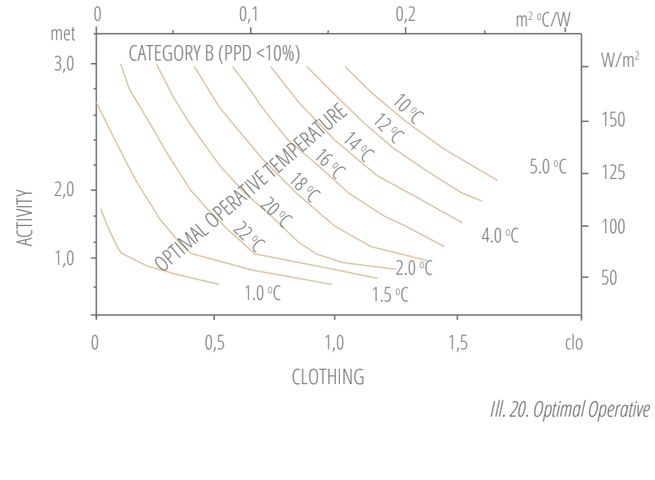
As a circular building, Ouroboros aims to use renewable energy resources for its operational energy demand, as they are infinite. At this moment, there is no option to choose an energy provider that can verify that they supply only energy that comes from renewable sources in Denmark. This leads the design to include a renewable energy harvesting system that utilizes the characteristics of our site and building, in order to power Ouroboros with renewable energy to the possible extend. Additionally, the European Commission plans for all new buildings built from 2020, have to be nearly Zero Energy Buildings (nZEB) (Agostino et al., 2016), and for Denmark, that means that the building has to fit into the energy frame Low Energy, which, for non-residential buildings, equals to 33,0 kWh/m2year. The site gets plentiful sun and has no shadow coverage from its surroundings. Additionally, it is spacious enough to allow for the building to be low-rise, which is preferred, since it is expected that part of the users may have mobility difficulties, yet it is desired that all have access to nature. Under these parameters, the installation of PV panels appears to be the most appropriate for supplying the building with energy to operate. Notably, though, PV panels are polluting throughout their life cycle. For this reason, our building design aims to reduce the operational energy demand in order to reduce the PV panels needed to be installed to power the building. The main strategies to be applied in order to reduce this demand are to design a building envelope that is insulated sufficiently in order to achieve low thermal transmittance and to ensure the flow of natural ventilation in order to reduce the need for mechanical ventilation, while, lastly, the focus has to be given on providing sufficient daylight to the interior of the building, appropriate to the use of each space, in an attempt to reduce the need for artificial lighting. Having ensured that the building requires the minimum amount of energy to operate, we still need to evaluate that installing the PV panels is a sustainable option, on the terms that it results in more benefits for the environment than what it causes throughout the life cycle of the panels. Likewise, the demand for operational white water can be reduced by using rainwater, when this is possible. Ouroboros facilitates several users and has large areas of greenery, therefore the savings from using rainwater for toilet flushing, laundry washing, and irrigation should be considered. In order to achieve greywater sufficiency, a rainwater harvesting system will be installed on the building, to ensure the utilization of this natural source available on site.

Category	Thermal state of the body as a whole		Local Discomfort			
	Predicted Percentage of Dissatisfied (PPD)	Predicted Mean of Vote (PMV) Interval	Percentage of Dissatisfied due to Draught (DR)	Percentage of Dissatisfied due to Air Temperature Differences %	Percentage of Dissatisfied due to Warm or Cold Floor %	Percentage of Dissatisfied due to Radiant Asymmetry %
A	<6	-0,2<PMV<+0,2	<10	<3	<10	<5
B	<10	-0,5<PMV<+0,5	<20	<5	<10	<5
C	<15	-0,7<PMV<+0,7	<30	<10	<15	<10
D	<25	-1,0<PMV<+1,0				

Ill. 18. Categories of Thermal Comfort, Source: DS/EN 16798-1:2019, p. 46,48



Ill. 19. PMV/PPD, Source: CR 1752, p. 13



Ill. 20. Optimal Operative Temperature, Source: CR 1752,p. 16

INDOOR CLIMATE

The indoor climate has direct effect on both the well-being of the users and the learning ability of the kids (Dudek, 2015). To ensure the appropriate quality of the indoor climate of each area according to use, the project uses the Danish Building Regulations (BR18) in the aspects of indoor thermal, daylight, acoustic, and air quality. As the facility hosts users of different needs, here are explored the qualities that each user group needs to feel comfortable. The aim is to find the right balance under which all user groups can feel satisfied with the indoor climate of the facility.

THERMAL COMFORT

The perception of the indoor thermal environment lies on both personal and environmental parameters (Fanger, 1999). The personal parameters are the activity level (met), and the clothing (clo) of each user. The environmental parameters concern the air temperature, mean radiant temperature, air velocity, and air humidity. Using CEN CR1752, the project aims to achieve the targets of category B, therefore the Predicted Percent of Dissatisfied (PPD) should not exceed 10%, regarding the thermal state of the body as a whole. PPD in relevance to the Predicted Mean Vote (PMV), which varies from -3 for cold to +3 for hot, is forming the frame under which the users should feel thermal comfort. The Danish Standards suggest that in order to reach the PPD of below 10% in occupied zones during the winter, the temperature has to be 20-24 OC with 1,2 met and 1 clo in the winter, while in the summer, it is expected that 23-26 ^{0}C can be achieved with 1,2 met and 1 clo (Jensen, 2014). The Danish Working Environment Authority reports that educational institutions and offices should have a temperature of 20-22 ^{0}C at most times, with a daily range of 4 ^{0}C (Arbejdstilsynet 2008). On the other side, the elders are expected to have lower activity rate as they are less mobile, therefore require higher temperature (Møller & Knudstrup, 2008). To achieve a dissatisfaction level lower than 10%, the temperature has to remain at 22-24 ^{0}C, considering for them 1 met and 1 clo. However, the activity of kids is expected to affect the room temperature, therefore this range is used in the private rooms of the elders. Finally, the extreme weather conditions are expected to influence the indoor thermal environment, however the target is for it to not exceed the 26 ^{0}C for more than 100 hours and 27 ^{0}C for more than 25 hours annually.

ATMOSPHERIC COMFORT

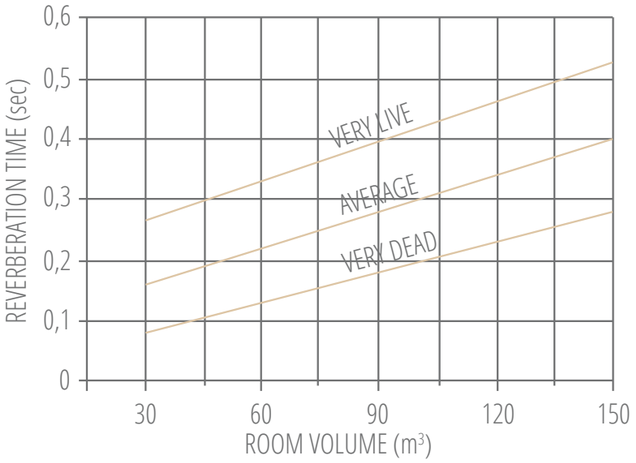
The good quality of the indoor air is key for maintaining good health of all users and even improving the learning ability of the kids. The required ventilation rate to achieve good indoor air quality is going to take under consideration the concentration of carbon dioxide (CO_2) and the sensory pollution (olf) of the indoor environment. The Danish building regulations suggest that kindergartens should use ventilation with heat recovery and minimum of 3 l/s per kid, 5 l/s per adult, and 0,35 l/s per m2. According to Indoor Climate Portal (indeklimaportalen.dk), the Danish Working Environment Authority recommends that classrooms do not exceed the CO_2 concentration of 1000 points per million (ppm). As the mobility of kids results higher pollution than the daily activities of the elders, it is expected that having the ventilation dimensioned according to the kids demands will satisfy the need of the elders for good perceived indoor air quality too.

VISUAL COMFORT

Provision to plentiful daylight has proven to reduce stress, regulate the circadian rhythm, and reduce the symptoms of depression (Dudek, 2015). These factors directly affect the well-being of the users, and, according to Dudek, studies confirm that this improves drastically the learning ability of the kids. Namely, it appears that classrooms with most window area have proven to help the kids improve in a rate of 15-23% faster and classrooms wit skylights are linked to improvement of learning ability rate of 19-20%. To achieve abundance of daylight, BR18 suggests that dining rooms and classrooms have openings of 10% of the floor area (bygningsreglementet.dk § 379). Additionally, DGNB recommends that a minimum of 2% daylight is required in 50% all the usable floor area (DGNB GmbH, 2014). BR18 also emphasizes the need for access to the outdoor view for all the users (bygningsreglementet.dk § 378), therefore it has to be ensured that both kids and elders being in a sedentary position get plentiful outdoor view.

ACOUSTIC COMFORT

The acoustics of the building are highly important as the behavior of the two main user groups differs dramatically, as elders tend to be quiet, while kids tend to be loud. The target, though, is for the building to have sound and comfortable sound conditions in all



Ill. 21. Perceived Acoustic Quality, Source: Marshall Long, 2014, Architectural Acoustics (Second Edition), p. 15

area, according to the use of each space. The acoustic quality of the indoor environment of the building is going to be measured in reverberation time, and in general, in the spaces that kids use, the aim it to strive for having low reverberation time, deader sound and higher absorption of higher frequencies, as the kids' voices tend to be high pitched, and high clarity, as the elders often deal with hearing issues. To achieve this, it is desired that areas such as classrooms and other public rooms will have a reverberation time below 0,5 sec (Long, 2014), while other areas, such as the private rooms of the elders or the singing area of the kids and elders should have different needs. It is important to understand these different needs from the early concept phase, as acoustics can be regulated not only from the use of sound absorbing building materials and furniture, but also from the building layout and shape itself, for example, non-parallel walls allow the sound to diffuse quicker than parallel.

DESIGN FOR THE FUTURE

As stated previously, the building industry uses an analogically high amount of the total available resources and is responsible for the production of sizable amount of carbon emissions and material waste. Having realized that the material and energy resources that the building industry currently relies on are finite and that our current mainstream handling of these resources damages the health of the ecosystem, there have been developed strategies to facilitate the transformation of architecture towards including the currect societal concerns of the sustainability of the future generations, by adopting the circular economy model.

According to the circular model, regarding the building materials, it is encouraged that they are manufactured and used in a way that allows for them to stay in the market loop for as many life cycles as possible. This tactic can reduce the need for raw material extraction and therefore reduce the environmental impact caused by the process of producing new materials, while also it is expected to allow the building materials to maintain their economic value, as they are not anymore destined for a single use before ending to landfill, as well as their cultural value, as they may be reused from one building to the next without being processed, therefore maintain character. While considering ways to harvest these benefits, it was concluded that the most prominent way is to use the methodology of Design for Disassembly.

Design for Disassembly of buildings can benefit the industry on multiple levels, from maximizing the life span of each building material and minimizing the need for new building materials to be manufactured to reducing the time required for buildings to be constructed and reducing the pollution being produced from all the life cycle stages of a building (Guy Brad, Ciarimboli Nicholas, 2006). Additionally, it enables the adaptability of the buildings, which is required as the always-evolving technologies and lifestyle transition the needs and demands that users have from their spaces. The strategy, therefore, carries a great potential in reducing the environmental impact of the building industry, however for it to be fully effective, it is important to understand that the discussion of the environmental impact of a building has to be taken to a current and future life-cycle level and that all the involved stakeholders are responsible for the proper handling of the building materials.

Throughout this project, the role of the architect and engineer is explored in a design for disassembly building. The earliest that the strategy is applied to a project, the more effective it can be, as it concerns critical design decisions. In our symbiotic facility of kids and elders, design for disassembly was determined to be followed from the early concept phase and therefore can shape decisions regarding the choice of materials, joints, component sizes and so on.

MATERIALS

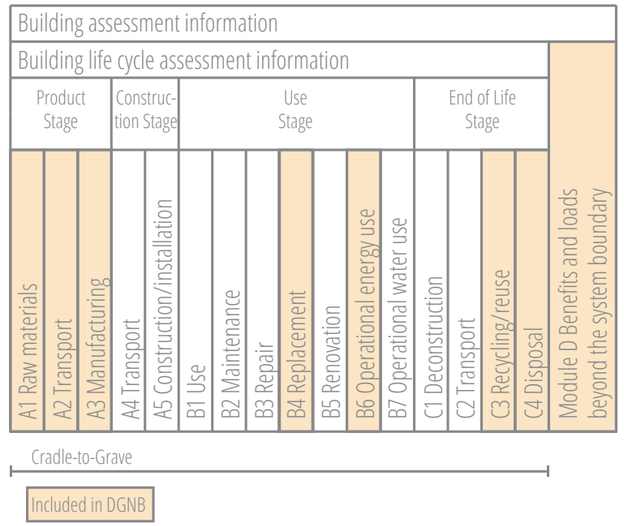
The materials to be preferred are non-toxic, natural materials. These materials can often be reused or recycled without causing pollution and sometimes are biodegradable or dissolvable. This way the environmental impact of the building can be low while the process of recycling and recovering energy from the materials should have a reduced environmental impact as well.

CONNECTIONS

The connections must be simple, of standard sizes, few in variation and minimum in use. Also, they must be easily accessible to the workers and easily reversible. These features will allow for the process of assembly and disassembly to be quickly done and with minimum damage to the components. To achieve this, steel connections such as bolts and screws of standard sizes are recommended for use. Steel can be pollutant, particularly when recycled, and is not considered regenerative, however the steel connections have a big life span and therefore can be directly reused on future projects without requiring recycling, while also are easy to install and remove when needed.

COMPONENTS

The components of standard industrial sizes should be preferred, while additionally it is recommened for them to be in relevance to the human scale, for the ease of assembly and disassembly. In the case that this is compromising the aesthetic quality of the building, there will be a strive for using components that have equal life cycle to the building, in order for them to go for recycling by the end of life of it. Also, all components need to carry their Environmental Product Declaration (EPD) so that the environmental impact of the building can be documented.



Ill. 22. LCA Stages, Cradle-to-Grave System boundary, and phases included in DGNB

LIFE CYCLE ASSESSMENT IN THE BUILT ENVIRONMENT

Life Cycle Assessment (LCA) for buildings is a methodology that allows the engineers, architects, and consultants to quantify the environmental impact of the building and inform the design process to reduce it. It is an internationally standardized method (ISO 14040 ff) that measures the environmental impact of a building during its lifetime. The assessment segregates the life cycle of a material, component, or building, in stages and different stages are selected according to which part of the product's impact one wishes to assess. In this case, it is required that the impact of the whole lifetime of the building can be assessed, while, additionally, there should be observed the possible benefits that occurred from the first life cycle of the building into a future life cycle. In order to include all the stages, the Cradle-to-Grave approach should be used.

The Cradle-to-Grave life cycle of a building includes the environmental impacts produced in the Product Stage (A1-A3), the Construction Process Stage (A4-A5), the Use Stage (B1-B7), and the End of Life Stage (C1-C4). The Product Stage (A1-A3) refers to the raw material harvest, their transport to the appropriate manufacturing unit, and their manufacturing into construction materials. The Construction Process Stage (A4-A5) includes the transport of the materials to the construction site and the construction of the building. The Use Stage (B1-B7) refers to the impacts caused by the use, maintenance, repair, replacement, and renovation of the materials and components, while it additionally includes the operational water and energy impacts. The End of Life Stage (C1-C4) refers to the demolition of the building and the transportation of the materials to either a recycling unit or to a landfill site.

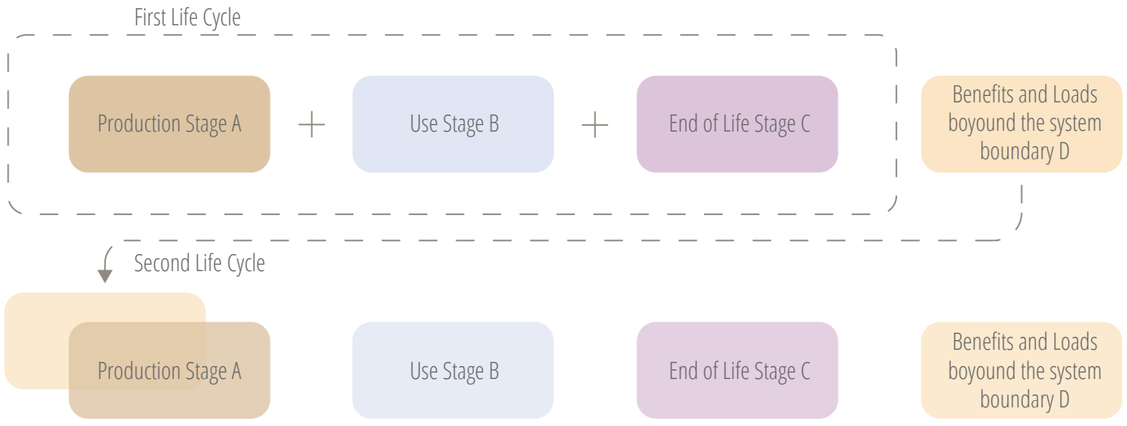
The quantification of the impacts is translated into some indicators that are measured and included in the EPD of every material or component. These indicators concern the carbon footprint of the product, the impact it has on the Ozone layer, as well as its effects on the flora and fauna. Regarding resources, the LCA indicators quantify the depletion of the material resource and the depletion of an energy resource that is caused by a product, as well as the primary and secondary energy required during the lifetime of a product. It is evident that these parameters affect both the health of the whole ecosystem, with the humans being included in it.

DGNB FOR LIFE CYCLE IMPACT ASSESSMENT

DGNB is a certification system for sustainable building that is commonly used in Denmark (Jensen, K.. Birgisdottir, H. 2018). It is considered to be well balanced between the social, environmental, and economic impacts that it evaluates, however in this report, it is going to be used to evaluate the environmental impact of the building, as it provides a user-friendly framework for evaluating the environmental impact of a building through Life Cycle Assessment. The evaluation of the impact of the potential materials and components of Ouroboros is expected to inform the design decisions, in order to achieve a great DGNB score, which would indicate that the building can be considered environmentally sustainable, regarding its life cycle impact.

For the calculation of the impact of a building, DGNB includes the indicators of the Global Warming Potential (GWP), the Ozone Depletion layer (ODP), the Photochemical Ozone Creation Potential (POCP), the Acid Potential (AP), and the Eutrophication Potential (EP). GWP refers to the carbon dioxide emissions that are directly linked to the phenomenon of climate change. ODP concerns the concentration of ozone in its layer, which is valuable to our ecosystem as it operates as a shield against UVA and UVB radiation. POCP measures gasses, such as hydrocarbons, that can create smog pollution, which affects the respiratory system of humans and other animals, as well as the health of plants. AP measures the acidifying emissions that contaminate the air and lead to creating the phenomenon of acid rain, which is damaging the plants and polluting the soil. EP quantifies the harm caused by releasing more nutrients than needed to the ecosystem, leading to the eutrophication of the flora, that can be poisoning to the fish if consumed.

DGNB provides weighting factors for these indicators. Global Warming Potential (GWP) has a weighting factor of 40% to the total score, while the rest has 15% each. The result of this assessment makes for 7,9% of the share of the total DGNB score of a building.



Source: Rasmussen F. N. et al., 2019, Upcycling and Design for Disassembly – LCA of buildings employing circular design strategies, p. 4

INCLUSION OF BENEFITS AND LOADS VIA DESIGN FOR DISASSEMBLY

At the time that one life-cycle of a building is completed, there are some benefits, as well as loads, that occur, and they are calculated in Module D, which refers to the environmental impact of a building beyond its life cycle, that can be considered only through using the building methodology of Design for Disassembly. Ouroboros aims to be a building that prefers the use of pure materials that do not include harmful glues or other toxic adhesives and relies on metal joints and screws for its component connections, while additionally, it promotes the application of dissolvable surface coatings. Following this concept, it can be ensured that the materials and components that are healthy for use on a next project can be reused and that the recycling and incineration process will result in more benefits than loads to the environment. These impacts are not included in the life cycle of the building that produces them but can be subtracted from either the production impacts of a future life cycle of Ouroboros or from the production impact of another building that makes use of the end products of the materials of Ouroboros. The particular approach of allocating the environmental impact between life cycles is called 100:0 and refers to the process of including the benefits and loads of the complete life cycle of the building into the Product Stage of the following life cycle, in order to avoid double-counting this impact (K. Allacker et al., 2014). The principal diagram illustrates the 100:0 impact allocation. It is important to be noted that Module D excludes the benefits and loads when these are calculated in the End of Life Stage (C1-C4) of a building material or component. The building methodology of Design for Disassembly is expected to allow us to make use of these benefits and loads instead of allowing the building materials to end to a landfill site.

ECONOMIC SUSTAINABILITY WITHIN THE TRADITIONAL DESIGN FRAMEWORK

While examining the benefits of merging these two facilities into one, there was developed the hypothesis that this typology should provide not only social but also economic benefits for the users and the stakeholders. The reason for this is that, through the merge, we hypothesized that multiple rooms, such as the activity rooms, can be shared between the user groups, while rooms like the kitchen and the administration area are required once instead of twice, which would be the case if the two facilities were built separated.

The stated hypothesis received confirmation via the study of Jarrott et al. (Jarrott, Schroeder and Perkins, 2008), who completed a study of measuring 75 buildings of facilities with both kids and elders, that have different levels of operational integration (i.e. shared operational expenses), regarding parameters such as building area, rent, personnel, operational electricity demand and so on. The findings showed that the cost of the rent and the personnel make 95% of the total operational costs in such facilities. Analytically, regarding the rent, it was found that sharing operational expenses between the user groups is related to the square meters and that up to 5 sq. m per participant fewer are required in facilities with maximum shared operational expenses. This reduction of required built space equals the reduction of rent for the users, but also reduction of the embodied and operational energy demand of the building. Additionally, it was found that the sharing of personnel between user groups can be financially beneficial for the users, as the personnel finance can require up to 3,7 times more in separate counterpart buildings compared to merged ones.

Taking this information into consideration, we expect that we can have savings on the required built area on the space required for the kids, elders, and personnel. This leads to two possibilities; firstly, there is the option for reallocation of saved space into other areas of the building, or secondly, there is the option for removal of the space and decreasing the cost of the building. A compromise between these may also be possible. Although the first option seems to be better for the people inhabiting these places, there are external factors that could prove problematic. In Danish nursing homes, people can get financial support for rent. However, this depends on a couple of conditions, firstly how much space is there per unit. Secondly, does the occupant have mobility problems? Thirdly, how many people live in these units? (Ældresagen, n.d.) Likewise, kindergarten has a similar system in place which denotes the square meter per kid (Statens Byggeforskningsinstitut, 2018). The formation of the program of Ouroboros will allow the team to observe which amount of the minimum required space according to use can be saved and which can be reallocated to provide better architecture quality, without compromising the right of the users to get financial funding for using the facility.

CIRCULARITY: SUB-CONCLUSION

The adoption of the circular economy model from the building sector is expected to allow it to decrease its polluting emissions produced throughout the whole lifecycle of a building, as well as its energy demand and material waste. This should result in long term benefits for the health and economy of the humans, as well as for the health of the rest of our ecosystem. The model has been analyzed using the 4R framework for the team to set clear objectives on how we expect that applying it will help us in reaching these goals. As architects, we tackle this concept from an additional perspective to understand how we can apply it in our social interactions, and particularly in this case in the social interactions taking place between the Ouroboros users. Therefore, apart from the environmental and spatial benefits, the team expects that the community of Ouroboros will manage to redirect the skills and experiences of one of the user groups into helping it to redefine themselves in this new phase of their lives and improve their quality of life alongside with the quality of life of the other main user group, which is the kids. It can often be observed that one of the stages of one circle may affect another circle, meaning that all three analyzed circular flows interact and synergize.

The quality of the human experience of the building user is affected by what they directly perceive, such as a comfortable, inclusive, and engaging environment, but also by the things that are perceived in a more subtle dimension, such as the indoor environment quality. To ensure its appropriate design, the team focuses on reaching thermal, atmospheric, visual, and acoustic targets appropriate to facilitate the learning process that kids are ongoing while setting different goals for the elder units, as they have different behavior and therefore different indoor quality needs, such as demand for higher temperature, due to reduced mobility, and additional acoustic insulation, as their living units co-exist with a kindergarten.

Focusing again on the health of the user, but from a different, yet very relevant, perspective this time, it is important to follow the circular model principals for the built environment, which includes reduction of material waste and utilization of available, renewable energy and water resources, alongside with the promotion of use of low-polluting, natural or recycled materials and components that can be disassembled without being damaged, to the possible extent, and the documentation of the used materials and environmental footprint they cause. All these three elements have to be combined to achieve the biggest feasible environmental impact reduction and long-term sustainability that may surpass the margins of environmental sustainability and benefit the well-being of the humans and rest of the environment.

- *Reduce waste and increase the circulation of the building's recourses on human, space, and building materials*
- *Use materials of low CO2 emissions during their complete life cycle*
- *Use of renewable energy resources*
- *Reach nZEB framework at minimum*
- *Use passive building design*
- *Utilize available greywater*
- *Follow the Design for Disassembly principals, meaning the use of low-polluting, non-toxic, non-adhesive materials, as well as the use of easily disassembled joints, and use of intentifiable materials, to ease the process of circulation*
- *Achieve temperature range of 20-24 OC during winter and 23-26 OC during summer in public areas, and 22-24 OC in areas used mostly by elders*
- *CO2 concentration may not exceed 1000 ppm at no indoor area*
- *Strive for visual access to outdoors from all areas and reach minimum of 2% for the daylight factor*
- *Public areas should have a reverberation time below 0,5 sec and additional sound insulation should also be installed in the elder units*

CASE STUDIES

Livs- og læringshus Hashøj
UN17 Village
Comparative study between a kindergarten and a nursing home
Sub-conclusion

Ill. 23. We Architects, 2018, Life and learning house

Ill. 24. We Architects, 2018, Life and learning house

CASE STUDY: LIVS- OG LÆRINGSHUS HASHØJ (LIFE AND LEARNING HOUSE)

This project, curated from WE Architects, includes a newly constructed daycare and an already existing, renovated school, and the aim is for them to operate as one and invite the local citizens to participate in activities throughout the day, at times when there is available space in the buildings. The project manages to reduce the need for new material, as it integrates the already existing educational buildings and chooses to renovate them. In the complex, there has been added a multi-purpose common room, in which the users of the school and the daycare are invited, as well as the locals of all ages, including the elder residents of a nursing home that is built in proximity. This common room will be equipped with some fixed activities, such as a library and learning furniture for the kids, but additionally it will have more generic areas to be customized according to the needs of each event, which could be a lecture, a concert, etc.. Finally, the common room is designed in a way to encourage the users to socially interact. The buildings form the perimeter of a central outdoor area, which is expected to be used by all users of all ages.

Regarding the materials, the project achieves reduction of need for new building materials through renovating the existing facilities. It is not clear whether or not the building is using reused or recyclable building materials, however, based on the available official renders, there is a clear aim to use natural materials, such as wood, for the facades, the opening frames, and both the fixed and mobile furniture.

Built space is reduced as the project provides the common area for all the users, including the school students, the parents of the toddlers from the nursery home, the elders who live in a nearby eldercare facility, and so on. The space of the common room is reused throughout the day for multiple purposed and is flexible to the point that it can be adapted according to the needs of each hosted event. Instead of letting the already existing school turn to unusable waste, the renovation of it recovers the area where it was initially built.

This project appears to be fulfilling all our social circulation principals. Firstly, it aims to directly connect the nearby nursing home to the new building through footpaths and therefore facilitate the interaction of users from different age groups. This interaction should result reduction of the feelings of loneliness and isolation that users, especially elders, might experience, while it will allow them to interact with the younger generations and use their experiences to educate them. The daily intentionally designed interaction should create cultural coherency between the involved age groups. Finally, the encouragement through design for social interaction and mobility is expected to improve the health of all users and therefore recover socioeconomic benefits the whole of the local community.

Ill. 25. Lendager Group, 2018, UN17 Village

Ill. 26. Lendager Group, 2018, UN17 Village

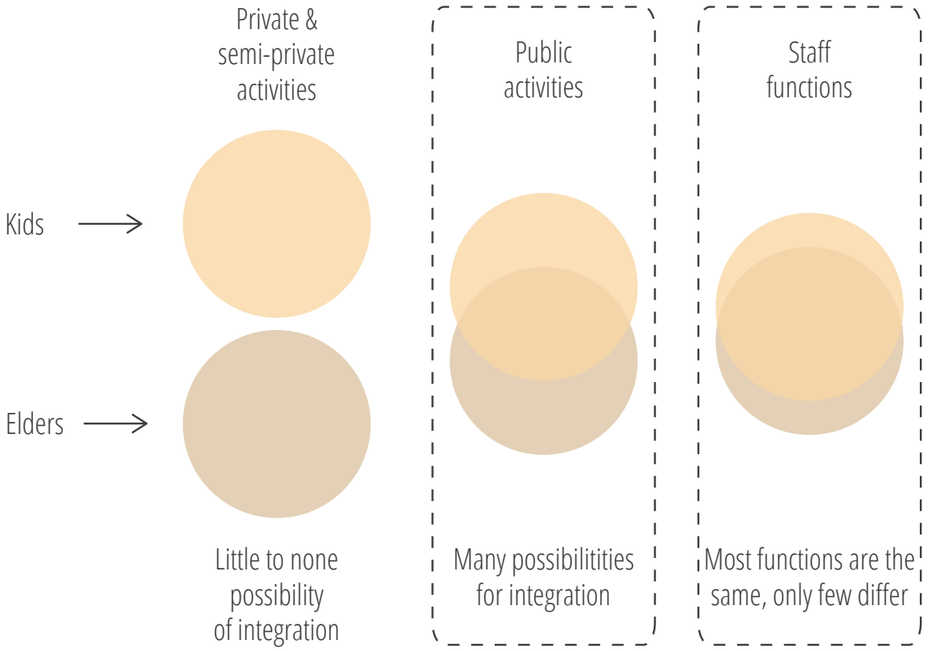
CASE STUDY: UN17 VILLAGE

For this project, Lendager Group and Aarstiderne Arkitekter have cooperated to design a mixed-use "eco-village" that corresponds to the United Nations 17 Sustainable Development Goals 2018, with focus on the use of renewable resources and the improvement of the health in communities. The complex will consist of recycled concrete, wood, and upcycled glass. Additionally, the plan is for it to be operating on renewable energy, while green roofs are expected to boost the biodiversity within the site, and rainwater collection should recycle 1,5 million liters of greywater per year. The construction's environmental impact is to be documented on a complete lifecycle. The design includes 400 residential units of 37 different typologies that are purposed for all different kinds of housing, including family housing, shared housing, elder accommodation and so on, with the purpose being this of mixing people of different characteristics regardless of age or family structure. Furthermore, 3000 m2 of communal spaces is dedicated to invites the residents of the nearby area to socialize and participate in the ongoing activities. A communal conference center is also to be included to host sustainability-oriented events, as well as an organic restaurant, a multitude of greenhouses, and food-sharing facilities, which should reduce the food waste in the complex while encouraging the users to get in touch with the nature. Finally, the operation of the complex is expected to create 100 job positions, resulting in economic benefits for the local community.

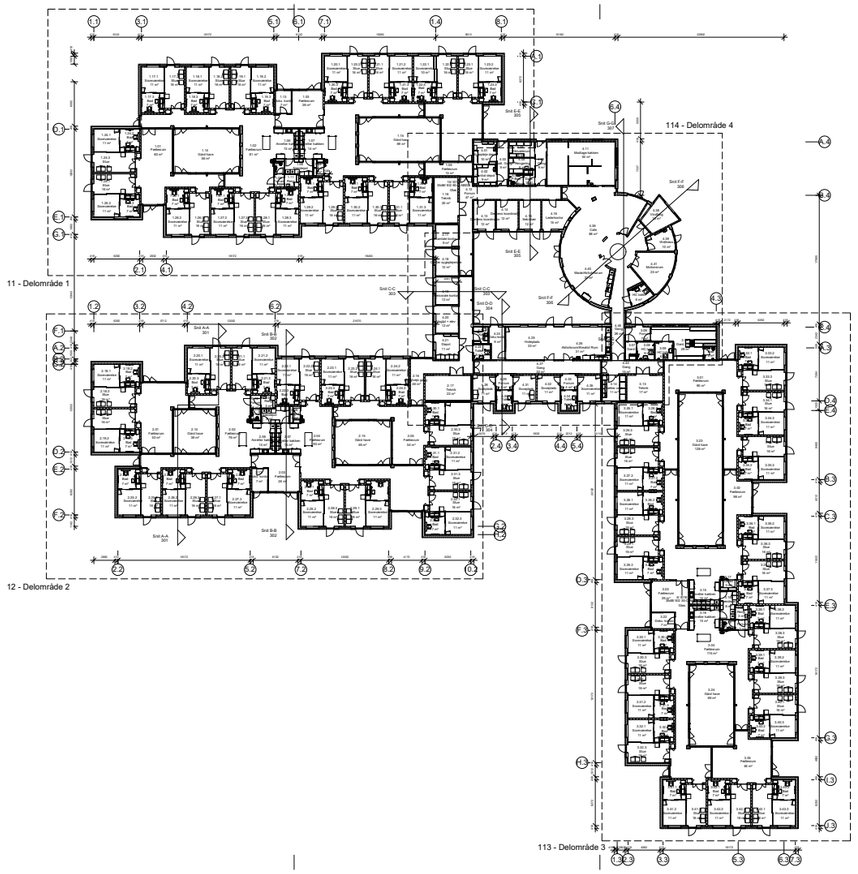
UN17 Village manages to reduce the need for new materials through using recycled concrete and upcycled windows. As it intends to document and reduce its environmental footprint on a whole lifecycle, it is understood that the materials and components to be used are going to be carrying their own EPD for documentation of their impact and identification for reuse in future projects. The use of construction wood will allow for future recycling and energy recovery that will cause reduced pollution. Additionally, it plans on relying on only renewable energy resources and on recycling greywater to reduce its operational water demand.

The spatial benefits of this design concern the built area and the space reuse. The multi-story clusters that consist the complex reduce the built area occupied by the multitude of implemented facilities, while the green roofs aim to invite the biodiversity in. Furthermore, the plentiful communal spaces allow for varied activities to take place throughout the day.

The co-existence of users from different age and family status, as well as the invitation of the nearby community to actively participate in ongoing activities of the area, should inevitably result in social interaction and therefore exchange of knowledge and skills within the community, while achieving cultural coherency. Through this, the users would be encouraged to get physically and mentally engaged and therefore their health and quality of life should be improved. In addition to this, the creation of new jobs should also contribute in the improvement of the socioeconomic balance of the community.



Ill. 27. Possibilities for spatial merge according to nature of activities



Ill. 28. Krogh Madsen Arkitekter A/S (2019) Det Nye Plejecenter

COMPARATIVE STUDY BETWEEN A KINDERGARTEN AND A NURSING HOME

As stated previously, it is logical that the need for built space and resources should be reduced when designing facilities with a high amount of intergenerational social environment. To verify this hypothesis, a comparative analysis, between two built Danish cases, is conducted. The projects are a kindergarten and a nursing home by Danish architect Krough Madsen Arkitekter. The first is a nursing home for people with dementia in Morsø with an occupancy of 45 people. The second case is a medium-sized kindergarten in Aars with a nursery.

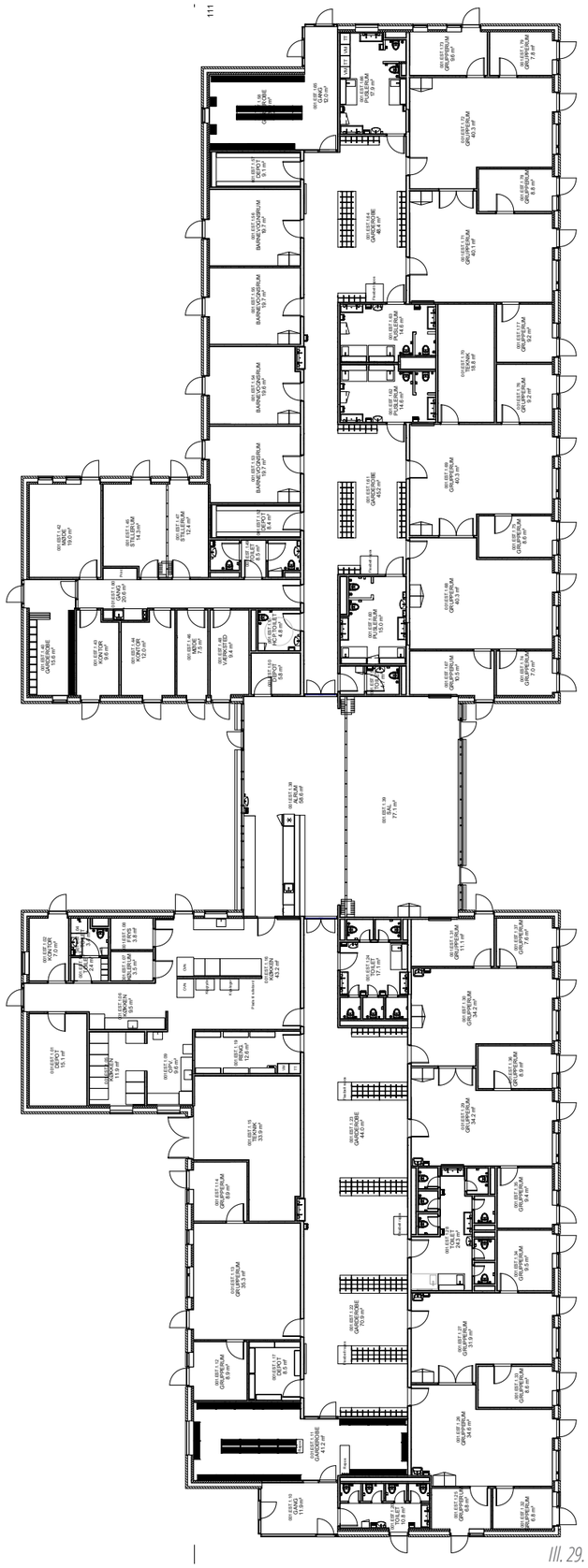
The nursing home's layout consists of 6 elder units laid out in three linear groups. These lead into a centralized hub of the community and staff functions laid around a courtyard. The layout has the effect of creating private areas for each elder group while strengthening the unity of the facility as a whole.

The kindergarten has a simple layout. The facility is laid around a central path through the entire facility. Every function is reachable from this pathway creating a space in which pathfinding and sectioning are made easy for the users. The staff functions, such as the kitchen and the offices, are placed towards the middle. The placement allows the staff to reach the children as quickly, in cases of emergency.

The two facilities, although handling different user groups, are similar in many ways. The layouts are comparable with a division of the users' areas, such as the kindergarten's group room and the nursing home's group units, and the areas of staff and activity, such as offices and halls. This allows the facility to create a sense of owned space for the users. The spaces become something belonging to the individual instead of the facility. Additionally, the facilities' layouts are created with a centralized and separate staff area. This allows the staff to quickly respond to emergencies.

The facilities share many functions which, in a combined kindergarten and nursing home, could be shared. In this paradigm, one could build the facility and save on the total allotted space of both facilities. Functions in these facilities come under three different categories. Firstly, is the user spaces, which are the main spaces for the children and elders. Secondly, is the activity spaces, which are the specialized spaces for users. Thirdly, the staff spaces, which are the rooms which the staff primarily use. In a joint facility, it would not be possible to create overlapping space within the user spaces. This is because of the integrity of these spaces would be compromised by the addition of the other user group. This would demolish any opportunity to create spaces which the users would take ownership of. Additionally, a separation of the user groups facilitates operations to continue as previously. However, activity spaces are a prime opportunity to create multi-use spaces which could be used throughout the day. The activity / creative room, the exercise room, and the common hall could be melted into a larger all-purpose room with partitions. This would facilitate spaces where the separate user groups could achieve their activities. However, it would likewise act as a space where intergenerational activity could occur. The staff spaces, likewise, could be combined between these facilities. Both facilities need office space for administration purposes, however, these administrational offices could be combined into one. Additionally, many of the other staff facilities can likewise be combined.

In a joint kindergarten and nursing home, it is advisable to create a clear distinction between the user spaces of the two user groups. The user spaces should be connected with activity spaces in between them. This would allow the user groups to individually create ownership of their respective areas while producing opportunities for intergenerational interaction. The staff spaces should be close to the user and activity spaces to allow the staff to respond in case of emergencies. Additionally, it would be possible to save space by merging comparable functions from each institution into one. This would allow the joint facility to become comparably smaller than the two facilities separate. This would allow increasing the quality of built space instead of the quantity.



Ill. 29. Krogh Madsen Arkitekter A/S (2019) DIS

Room	Area
Activity / creative room	31
Arrival kitchen	55
Cafe	88
Central nurse office	12
Central storage	9
Changing room female	28
Changing room male	4
Changing preroom	7
Cleaning room	6
Counceling offcie	9
Dementia coordinator office	12
Documentation office	9
Employee wardrobe	3
Exercise room	23
Guest sleeping space	11 x 4
Handicap toilet	6 x 3
Leader office	15
Meeting / activity room	32
Nurse storage	10
Pantry	8
Resting space	33
Secretary	12
Shift office	12
Staff toilet	3
Staff office	12
Storage	11
Technical room	17
Toilet common	6 x 2
Washing room	11
Wellness	10
Wind catch	25
Elder units x 45	
Bath	7
Bed room	11
Living room	16
Common area per group unit x 6	
Common room	81 + 60
Courtyard	69
Food preparatuib kitchen	14
Technical room	20

Ill. 30. Solrød Kommune and DK2 Byghererådgivning (2018) Byggeprogram, Del 1 - Arkitektonisk- of pædagogisk inspirationsprogram. Solrød

Room	Area
Baby room	60
Cleaning room	13
Common hall	77
Common room	59
Freezer room	4
Grould room infatns	40 x 4
Group room kids	35 x 5
Handicap toilet	5
Kitchen	65
Kitchen storage	24
Kitchen toilet	6
Kitchen office	7
Meeting room	53
Office	22
Side group room	9 x 18
Storage	27
Stroller room	20 x 4
Technical room	34
Toilet staff	9
Toilet kids	52
Refrigirated room	4
Wardrobe by group rooms	207
Wardrobe outdoor clothes	41 + 20
Wardrobe staff	16
Workshop	9

Ill. 31. Fredensborg Kommune and Kuben Managenent (2015) Byggeprogram - 1, værdi- og funktionsprogram, Fredensborg Kommune, Nyt pleje- og rehabiliteringscenter. Fredenborg.

CASE STUDIES: SUB-CONCLUSION

In the case study of the Life and Learning house, the connection between generations is achieved through connecting the old and new facilities hosting different age groups in the area. A flexible common room is created to host intergenerational interactions and events. Footpaths are used to direct users in public areas. The elder users' knowledge and experience are being transferred to the younger kids of the school and at the same time, this interaction is expected to be reducing their feelings of loneliness and isolation. This interaction should enrich the lives of all involved users and improve their health, resulting in socio-economic benefits.

UN17 Village strives to become a case study for sustainable building in all aspects and therefore many of its details can be useful for the project. On a behavioral level, it aims to bring the users closer to nature and educate them through daily life and targeted events about sustainability, while encouraging activities such as food-growing, food-sharing, and food waste handling. As it comprises a relatively big and complex area, it even attempts to create job positions that will ensure the smooth operation of all activities, while creating economic benefits for the local users.
Regarding its environmental impact, UN17 Village uses either already recycled building materials and components or materials that can have a big variety of recycling options, such as construction wood. It is also stated that it aims to use only renewable energy resources and harvest the available greywater to reduce the demand for white water.

Spatial circulation is achieved by reducing the required built area by stacking the apartments and other facilities, while several communal spaces are planned to exist that can be customized according to the needs of each activity to be taking place at each time.
Biodiversity is further enriched by creating green roofs.

UN17 Village strives for social circulation through strengthening the cultural coherency between users of different age and family status, as well as aims to invite the nearby residents in to participate in its community.

The comparative study between a kindergarten and a nursing home concerns the existing functions in each and the level of merging that can be expected out of combining the two facilities. In kindergarten, staff functions are placed in the middle for quick access to all areas. Ease of movement is ensured by designing spacious pathways, circulating in the building. Another similarity is that the staff, in both cases, is located somewhere centrally to interfere when needed, however in its own, separate area.

Sense of ownership of space from users shows in both buildings, as private or semi-private and public rooms are provided for them in both cases to facilitate their everyday routines.

Private and semi-private user areas exist in both cases and cannot be merged, as they facilitate the specific needs of each user group, e.g. an elder living unit or a kindergarten classroom. However, public spaces, such as activity rooms, can be merged, the degree of which is to be explored. Additionally, the staff specializations are partially the same and partially different, and therefore a merging should result in a bigger staff section compared to the staff section of any one of the facilities, but smaller than building the staff sections of both buildings separately.

- *Common rooms able to be adapted to the needs of several activities is common between the analyzed case studies, to reduce the need for built area.*
- *People living in the nearby area can be invited in after the underage users are no longer in the facility.*
- *The educational activities can include both seminars and practical activities revolving around sustainable ways of living, such as food-sharing, avoiding and utilizing food waste, food-growing and so on.*
- *Use of either recycled or recyclable materials and components, of which their recycling process creates low pollution is preferred.*
- *Utilization of available renewable energy and water resources is preferred*
- *The ability for the users to customize all of their usable area should enhance their sense of ownership in the building*
- *Staff can be placed centrally to have direct access to all users at any time.*
- *Ease of movement through spacious pathways should be achieved*
- *Staff functions concern similar occupations in majority between such facilities as a kindergarten and a nursing home, while many opportunities for spatial circulation should be available for the common activity areas.*

SITE ANALYSIS

Why Hillerød?
Location
Access
Serial vision
Site contours
Building functions
Typologies and heights
Municipal plan
Microclimate
Sun & shadow analysis
Sub-conclusion

4

WHY HILLERØD?

For the area in which we propose to build the shared facility, the city-scape will be changing in the coming years. Hillerød municipality has been working at revitalizing and transforming Hillerød into a city which favors sustainable building and business practice while promoting educational and social activities. These last two ideas are expressed through the municipality plan's motto "Lærings- og Livskraft," meaning the power of learning and life. Likewise, they wish to portray themselves in these values with a large focus on establishing and building green urban areas (Hillerød Kommune, 2017). The municipality has additionally shown interest in a joint kindergarten and nursing home project (Bachman and Olsesen, 2020). These factors make Hillerød a favorable setting for the project. The specific area we are expecting is lacking any specific plans form the municipality, however, just north of the site the municipality is currently underway in building parts of a multi-stage plan. The area they are constructing is going to be called Frederiksbro. It is supposed to become an environmentally sustainable area with mixed-use buildings and a high focus on establishing outdoor areas. The area contains a mixture of functions, building heights, materials, typologies, and user types. This should facilitate a diverse and lively city life. The buildings decrease in height and increase in density the more south they are placed. The Frederiksbro project seems to indicate that Hillerød wants to transform the desolate fields into a dense urban environment, while still maintaining the quality of the low dense urban space (Frederolsbro.dk, no date).

Based on the development shown by the Frederiksbro project it can be reasonably hypothesized that the municipality would seek to further develop the area south of the project. Additionally, one could conclude that these further developments would be of a lower and denser variety than the rest of the project. We would hereby assume that the area, in which the shared facility would be placed, would be built in the coming decade or so. Therefore, the project should take into consideration that the area around it would not be vacant for long and should be the start of this new era.

Ill. 32. The site

LOCATION

Hillerød is a medium-sized town in the Northern part of Zealand, just on the southwest of Copenhagen. It has 50.000 inhabitants and the city is characterized by its suburban feeling while the city center resembles a small scaled metropolitan area open to tourism, with the Frederiksborg Slot being its iconic cultural asset.

The specific site of the project is a lot of unused lands just south of the city centre. Close to Fredriksborg Slot, it can be considered to be as close to the heart of Hillerød as possible. Currently, it's surrounded by low rise family housing, summer houses, a high school (Hillerød Handelsgymnasium), and heathland. The vagetation is mainly developed on a near ground level, with trees scattered around. However, the plan of Frederiksborg suggests that the development of the area should focus on enriching the element of nature in the area (Frederolsbro.dk, no date). The elevation of the site is mostly flat, with a small inclination on the southeastern side.

Ill. 33. Map of Denmark with Hillerød highlighted

Ill. 34. Pedestrian/bike lane South to the site

Ill. 35. The main path to the site on its West

ACCESS

The site is connected to the main road on both its eastern and western sides. This is an advantage as there is direct connection for the users and the visitors to come to the building by car while also it eases the process of an ambulance coming to pick up one of the users in order for them to be taken to the town hospital, for the case that this is needed. The main road does not appear to be busy as for now.

Alongside the main road, on the western side of the site there is a bike and pedestrian lane. This can ensure that local people have easy access to the facility and encourages the adult users to take nearby walks when they are able to.

On its northern side, the site is connected to the distrubution network, which is expected to be used for specific errands, such as allowing the local residents to park in their neigborhood, therefore it is expected to be mostly quiet.

On the southeast of the site, approximatelly 400 meters away from it, there is a bus stop, which can be used by the staff for their everyday commute, the elders for visiting other areas in town, and visitors.

The understanding is that the access to the site is easy through walking, biking, car driving, and using public means of transportation. The exposure to the main road poses no issue as for now, due to the fact that it appears to not be used significantly.

Ill. 36. Access ways to the site

Ill. 38. Serial vision illustrations

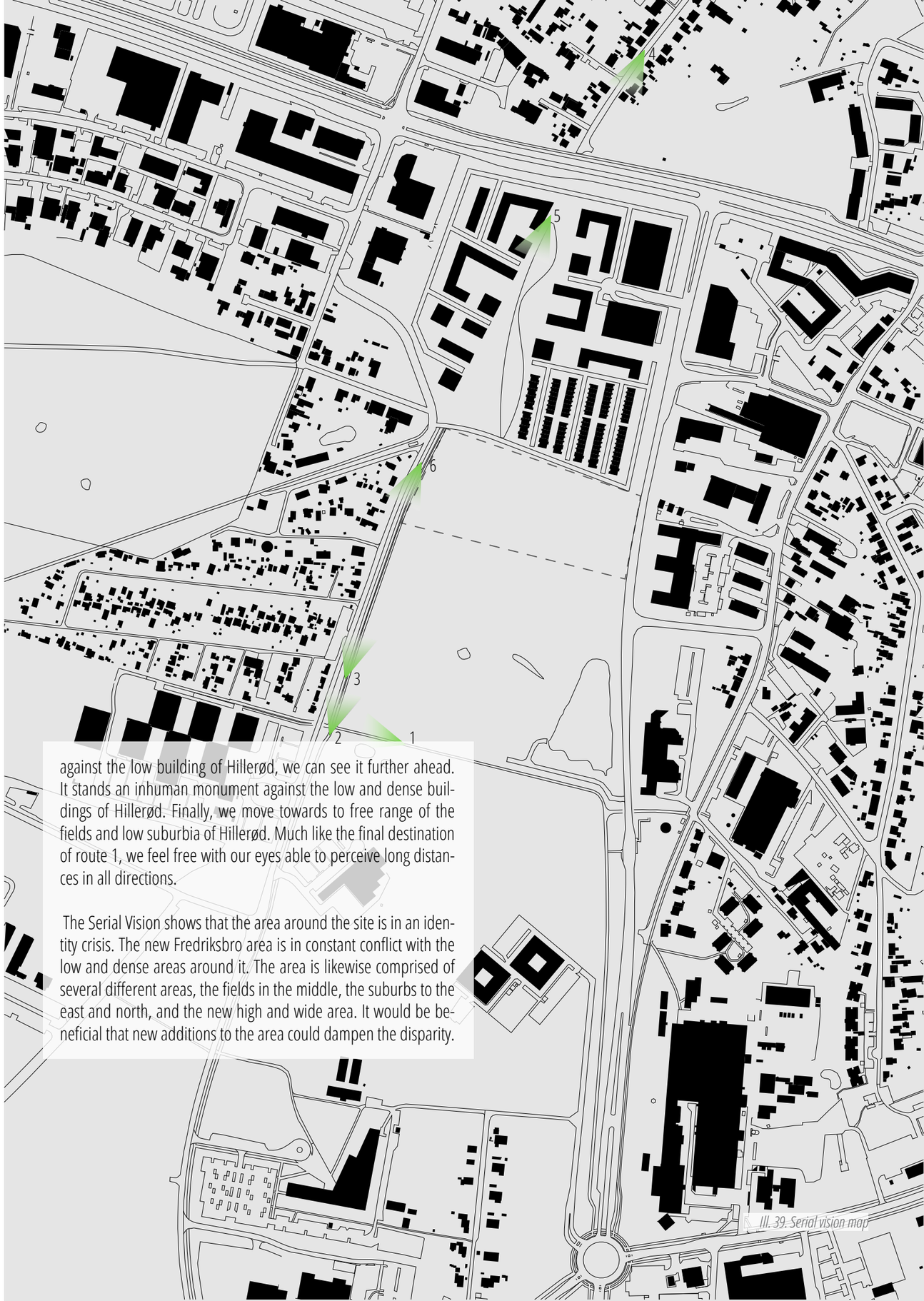
SERIAL VISION

Architects seem to favor certain views when designing, plan, section, and facades. However, these are abstractions of reality, and never indicative of how the users would perceive the built work. Together these abstractions are great at conveying the logic and purpose of the building and give some measure of how the building is going to be perceived. However, the eyes do not work in the parallel views of these drawings. It is vital when designing to consider the building in both parallel abstractions and in ocular perspective. Gorden Cullen describes a methodology in which he walks through a cityscape and in certain points he draws the city from a perspective viewpoint. He calls this method Serial Vision. This methodology helps in both analyzing and conveying the place of a given site. The place can be described within three categories, Optics, Place, and Content. *Optics* is the perception of the emerging surrounding area. *Place* is the innate human understanding of their position in relation to their surroundings. *Content* is the tangible elements within a given area that a human can perceive.

The site has two interesting routes of approach. Firstly, the route one starts at picture 1, just south of the site. The road here is an old biking and walking path going east-west. The pavement is cracked and uneven. The flora attempts to envelop it. The buzzing of midsummer insects and cars can be heard in the distance. It continues straight for a long while. The second picture turns us north on to segregated biking and walking paths, just as we pass underneath an animal bridge. A tunnel going under the road leads would lead us away from our given path. The paths start to climb to level out with the road. The third picture sees us climb the incline to be opened op on all sides, to stand free. The site, which is currently a field, sits to our right, while a suburban area sits to the left, lowered in relation to the road. In the distance, one can see the rest of Hillerød and the area which will become Fredriksbro.

The second route starts in a suburban area to the north. We stand on a road with two-story houses on both sides, green front gardens segregated by hedges. People come here for one purpose only, coming home. Kids would be playing on the road when possible and the bustle of the main road can be heard ahead, moving further south over the main road we find ourselves at picture 5. In the currently under construction Fredriksbro. The place would become a green urban area with tall and wide areas that would allow for lots of activity here. However, the tall buildings stand out against the low building of Hillerød, we can see it further ahead. It stands an inhuman monument against the low and dense buildings of Hillerød. Finally, we move towards to free range of the fields and low suburbia of Hillerød. Much like the final destination of route 1, we feel free with our eyes able to perceive long distances in all directions.

The Serial Vision shows that the area around the site is in an identity crisis. The new Fredriksbro area is in constant conflict with the low and dense areas around it. The area is likewise comprised of several different areas, the fields in the middle, the suburbs to the east and north, and the new high and wide area. It would be beneficial that new additions to the area could dampen the disparity.



Ill. 39. Serial vision map

Ill. 40. Site sections - 1 : 5000

SITE CONTOURS

The contour lines have height difference of 0,50 m and the height difference within the site is 2,00 m, therefore the site is perceived as flat.

Ill. 41. Contour lines map

BUILDING FUNCTIONS

The site is surrounded by a multitude of residential buildings, seen in black in the functions diagram. This means that potential users of Ouroboros are already living in the nearby area.

In green there can be seen the educational buildings, which are the Hillerød Handelsgymnasium on the southwestern side of the side, the Center For Beskyttet Beskæftigelse on the eastern side, which provides education regarding protected employment to adults, and the Erhvervsskolen Nordsjælland on the southeastern side, which provides education to young people, regarding technical jobs. The presence of these educational insitutes indicates that there are kids that could use a kindergarten in the nearby area.

Red represents the nearby grocery shops. Although the facitliy aims to include a kitchen, it is hypothesized that the elder residents may want to use them in order to enhance their sense of independence. In close proximity to the site, on its northeastern side, there can be found the church Alive Frikirken. This may be used by any of the user groups, for spiritual purposes.

On the northern side of the site, there is currently under construction the Frederiksborg district, which is going to be a mixed-use area, however up to this date the functions to be included, apart from residencies, is unspecified (Frederolsbro.dk, no date).

Gray represents a big forest that can be used for educational or recreational purposes from both kids and elders. Other nearby facilities include the work spaces and retail shops, which can be seen in blue, while the municipality is located near to the site, on the south.

The study of the nearby functions leads us to the conclusion that the already existing residents could make use of an intergenerational facility such as Ouroboros, as there are many residential buildings on a close radius, while there currently is lack of either a kindergarten or a nursing home. Additionally, our facility can be an asset for the area, as apart from its educational and care-taking character, it aims to also be used for recreational purposes by both the users and the nearby residents. At the same time, the users of Ouroboros can also benefit from the surrounding context, as the site is close to cultural buildings, shops, and the nature, which can improve further the user experience.

Ill.42. Building functions diagram

Ill. 43. Residence across the site on the West

Ill. 44. Residence across the site on the West

Ill. 45. Educational institute on the South

Ill. 46. Under construction mixed-use district on the North to the site

Ill. 47. Apartment blocks on the North

Ill. 48. Under construction two-story rowhouses

TYPOLOGIES AND HEIGHTS

Here are presented the heights and typologies of the nearby built environment. The area already has a sensation of intergenerational symbiosis between buildings, as close to the pre-existing buildings are currently added new whole districts.

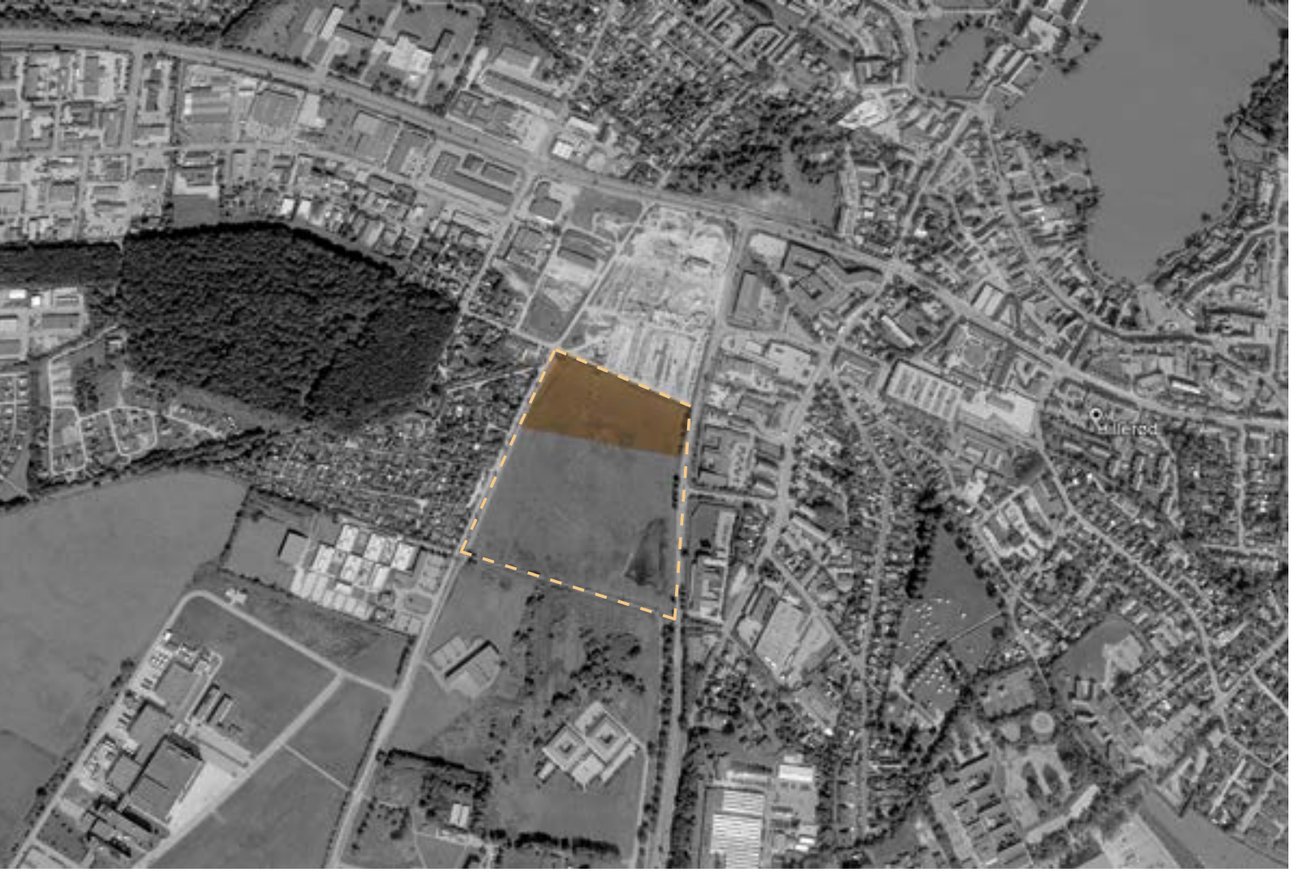
1: Suburban free-standing residencies, ill. 38, 39
On the western side of the site, the site across the street if filled with one to two-story houses. These buildings are characterized by their medium to high pitched roofs and use of brick.

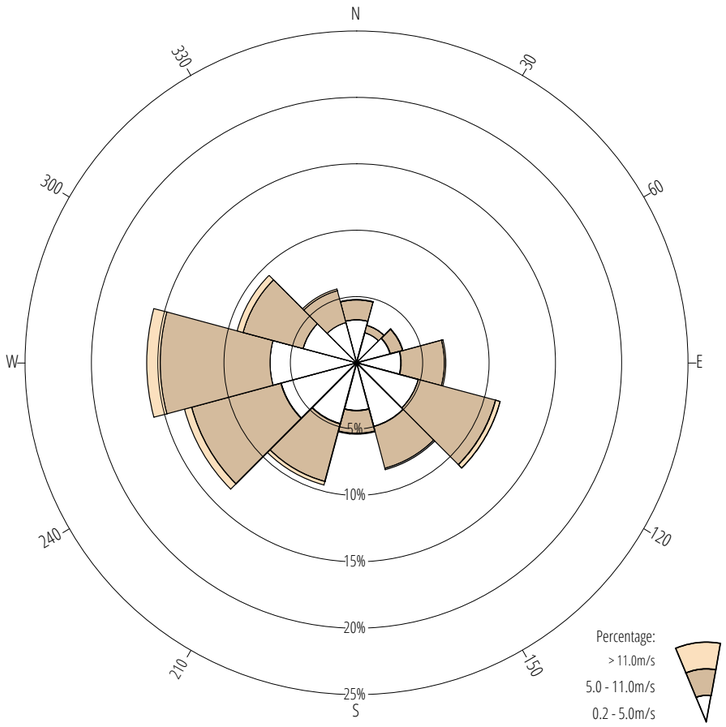
2: Apartment blocks, ill. 42
On the North there is a complex of three-story residential blocks, consisting of brick and ceramic pitched roofs.

3: Rowhouses, ill. 43
On the northern side of the site, there can be distinguished a new to the area building typology, the rowhouses. The specific ones are currently under construction, but it can already be observed that they are two-story residential buildings, of brick, with a mixture between pitched and flat roof, and with solar panels installed onto them.

4: Towers, ill. 41
Another addition to the existing landscape is the currently ongoing construction of the mixed-use district of Frederiksbro on the North, which adds the element of high-rise buildings into the neighborhood. The district includes 15-story towers and 3 to 6 -story apartment blocks, as seen in photo. Currently, it appears as a group of brick constructions, however on the internet there can be found renders of the final form of the district which include massive surfaces of either brick or wood facades (propstep.com, 2020).

5: Office and retail buildings, ill. 40
The office and retail buildings are made to the scale of their functions, in a comparably low height of mostly 2-story, and tend towards squared shapes, with either pitched, flat, or tilted roofs. They are scattered throughout the area and mostly form clusters.





Ill. 51. Windrose of Roskilde, Source: Dmi.dk

MUNICIPAL PLAN FOR THE SITE

Zooming into the site, the municipal plan of Hillerød characterizes it as part of a space that currently is a recreational area and should remain under this use in the future as well. Additionally, the plan states that no building may be erected. However, the plan has been released in 2017, and the current development in construction of building districts in the perimetrical area indicate that this part of the town is expected to attract a plethora of residents and companies, and, in addition to the fact that the site is well connected to the town's infrastructure, we argue that, in the near future, there is going to be a need for both a kindergarten and a nursing home. Furthermore, by combining these two facilities, we reduce the space required to be built, therefore allowing for most of space to remain available for public outdoor activities. Lastly, we suggest that Ouroboros can operate as a recreational space open to the local residents for activities that can take place after the running hours of the kindergarten (Hillerød Kommune, 2017).

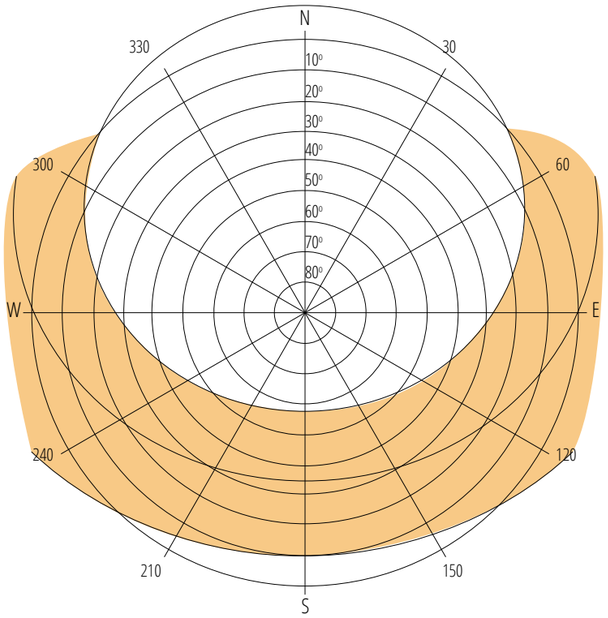
We believe that the municipality intentions alongside with the ongoing development on the area make the particular site ideal for a facility that hosts education and health services while promoting cultural coherency, like Ouroboros.

Ill. 49. The site including Northern surroundings

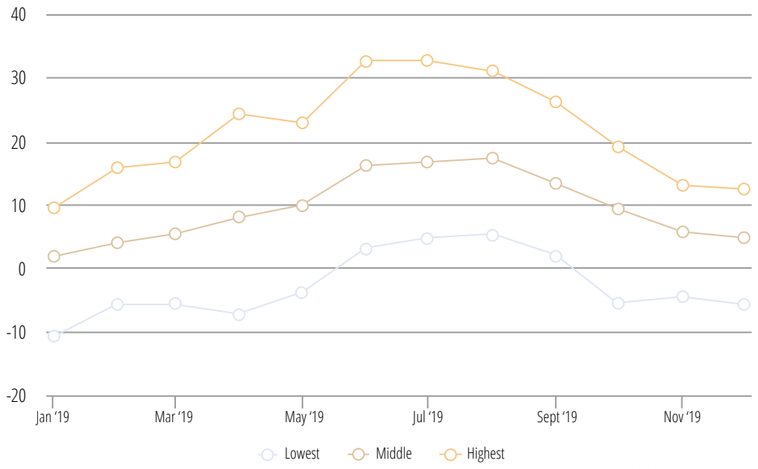
MICROCLIMATE

Microclimate concerns the atmospheric conditions of a specific area that develop in the air layers close to the ground (Deutscher Wetterdienst, no date). These conditions influence and get influenced by local elements, such as soil, vegetation, presence of other buildings, etc., and their textures and thermal properties, as these qualities can deeply affect aspects, such as the local temperature and wind speed (Deutscher Wetterdienst, no date).

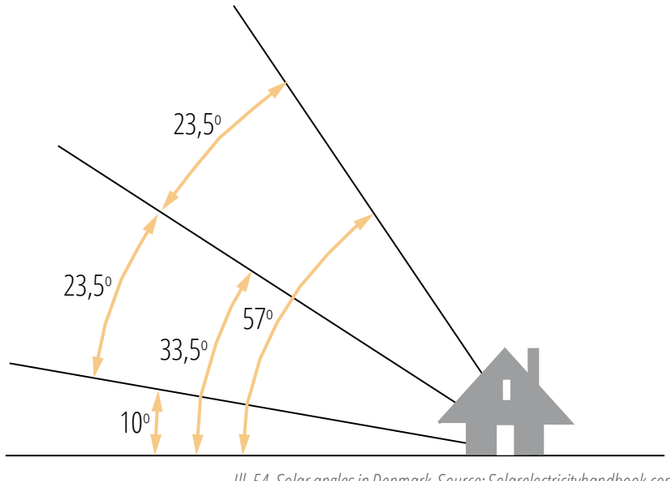
Our site is mostly flat and exposed to the wind coming from all sides, which certainly will require for the outdoor usable area to be designed with wind protection, at some extend, in order to increase the time that it could be used around the year. Additionally, the availability of fresh air from all angles invites our design to consider ways to allow the fresh air in and reduce the demand for mechanical ventilation. At the same time, the site, lacking shadowing from its surroundings, has access to abundant natural light from all sides, which can be invited in the indoor areas in order to improve the well-being of all users and improve the learning ability of the kids (Dudek, 2015), although the design has to find the balance between allowing the daylight in and avoiding overheating. The presence of both etiquette wind and solar power in the site creates the opportunity to choose for the ideal option as the building's main energy source. The site is filled with vegetation, which can be increased to create natural shadowing for the warm months, and on its eastern side, it abuts with a pond.



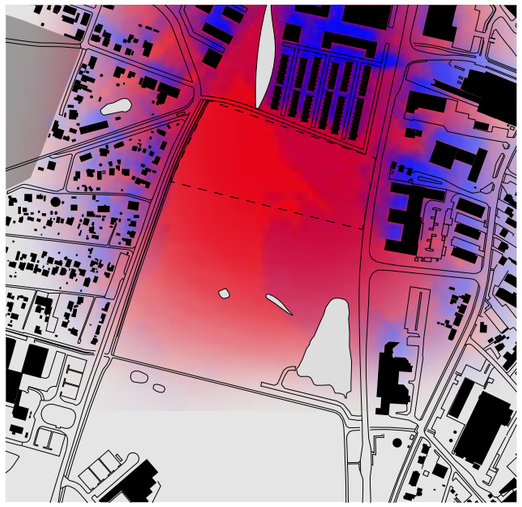
Ill. 52. Sun Path of Copenhagen, Source: Gaisma.com



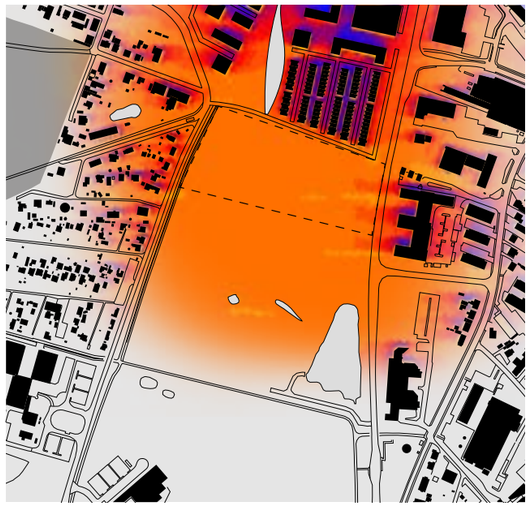
Ill. 53. Average temperature of Denmark for 2019, Source: Dmi.dk



Ill. 54. Solar angles in Denmark, Source: Solarelectricityhandbook.com



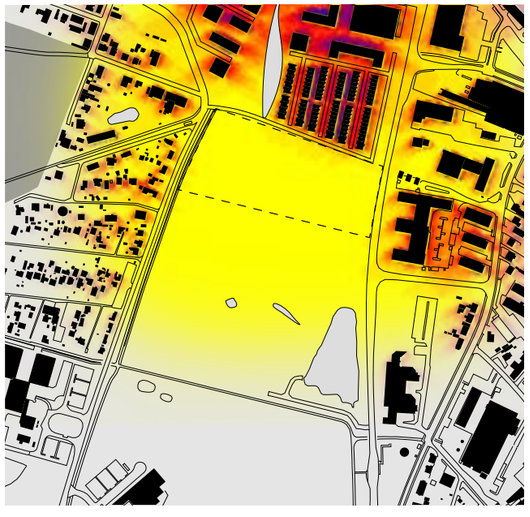
Ill. 55. Sun & shadow during winter



Ill. 56. Sun & shadow during autumn/spring

SUN AND SHADOW ANALYSIS

The solar conditions of the site are characterized by the sheer abundance of it. Because of the low buildings to the south and the flatness of the typography, there are not any sort of obstructions to hinder the daylight from reaching the building site. However, this otter lack of obstruction is a concern for the building and must be considered when designing the facility. In an institution with lots of people, who are in different levels of activity, one must make sure that the passive solar heat gain doesn't become too excessive and lead to overheating.



Ill. 57. Sun & shdow during summer

SITE ANALYSIS: SUB-CONCLUSION

Hillerød is ongoing through a transformation which favors sustainable building and social and educational activities. Additionally to that, the town has expressed interest in having a joint facility between kid and elder care. The site has been chosen as it is located nearby the city center, however in a quite suburban area, that has some existing residencies, while many more residential units are under construction at this moment. The site is well connected to the main roads of Hillerød, making the transport to the center and/or hospital easy, while it also is accessible via public means of transportation and bike and pedestrian lanes. The site is also well connected with a forest in close proximity, which the users could visit by feet.

The surrounding area already is equipped with educational institutes, such as elementary, middle, and high school, but not a kindergarten, while also the investment on creating more residencies at the area is expected to raise the need for a nursing home. Moreover, already existing nearby facilities, such as a church, a gym, and grocery stores, are expected to enrich the user experience of the elder users and allow them to maintain the sense of independence, in case this is wanted.

Although some of the new buildings, currently under construction, are designed to be high-rise, the vast majority of both the existing and under development buildings is low to medium rise. There is strong presence of old and new buildings, however, it can be observed that there is no coherency in the architectural language of the context. Ouroboros can be the link between the different eras.

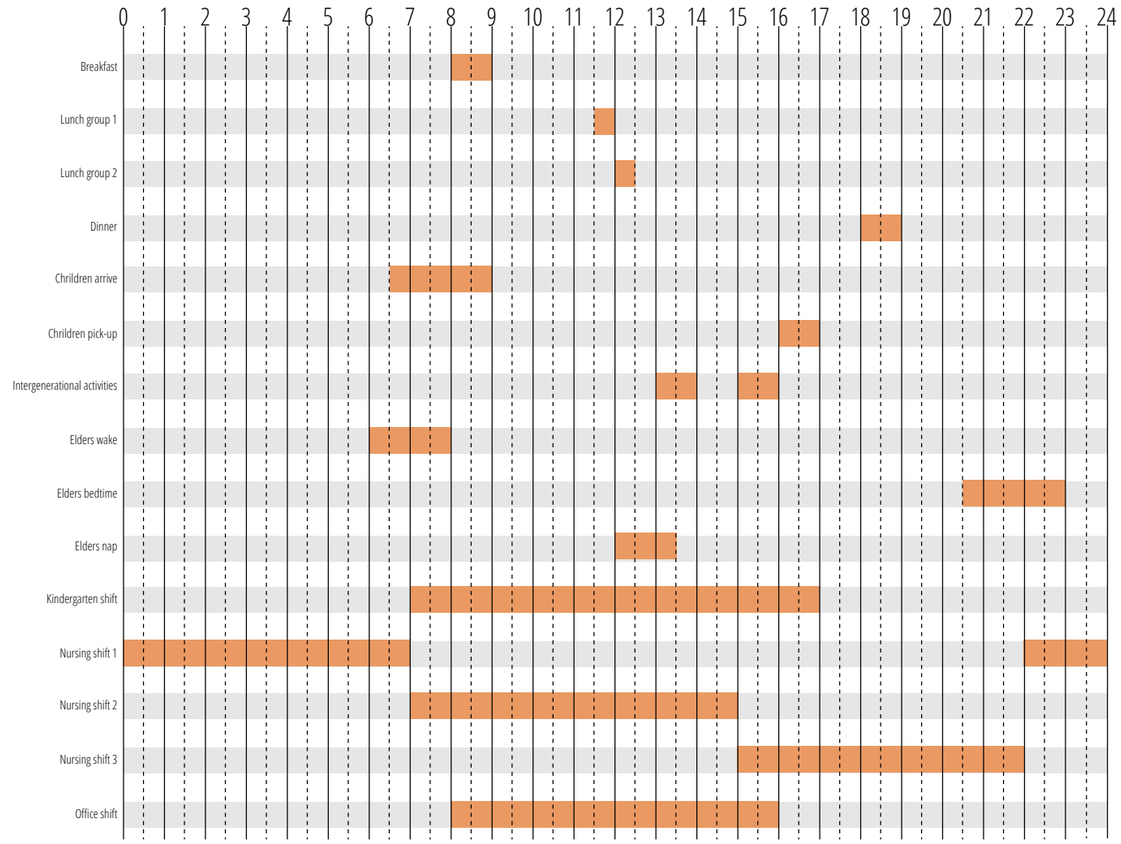
The chosen site has been characterized by the municipality as a recreational area and plans for no buildings to be erected on it, however, we argue that the rapid growth of the area, regarding residential buildings, will make the need of both a kindergarten and a nursing home essential, and we argue that by combining these two facilities, we reduce the required space required to be built, leaving the majority of the site free for recreational activities to be hosted in it.

The site has abundance of sun and wind. Through careful design, these elements can be utilized to reduce the need for mechanical ventilation and even improve the daylight factor above the required standards. Additionally, either sun or wind, or both, can be used to allow the building to be energy sufficient. However, it is important to keep in mind that the openings should be carefully designed to avoid overheating, and that the western wind can be strong, therefore it would be ideal to protect the outdoor areas from it. Finally, the vegetation on site is sparse and therefore can be increase, not only to enhance the element of nature, but also to possibly create shadows and wind barriers for the outdoor areas.

- *Hillerød wants to invest in sustainable building development*
- *The town has expressed interest in having a joint facility between kid and elder care.*
- *Site is close to the city center, but area is residential, suburban, and quiet.*
- *Site has great connection to essential facilities and recreational areas through multiple means of transportation.*
- *Surrounding buildings are mostly low to medium rise.*
- *Strong presence of old and new buildings, but coherency of architectural language is missing.*
- *The combination of the two facilities into one should reduce the required built area, leaving the majority of the site area available for outdoor recreational activities.*
- *The plentifulness of natural resources on site, such as sun and wind, can be utilized to improve the indoor climate of the building without increasing the operational energy demand, while additionally they can provide operational energy independence to the building.*
- *The vegetation can be increased to naturally protect the openings and outdoor areas from excess sun and wind exposure.*

DESIGN CRITERIA

Ouroboros philosophy
Time frame and maximum number of users
Room program
Function diagram
Design criteria
Vision



Ill. 58. Time schedule of users

OUROBOROS PHILOSOPHY

The underlying philosophy behind the Ouroboros project is the conviction that architecture needs to adopt the thoughts and principles of circular thinking. Although the strategy has been adopted in the technical aspects of architecture, i.e. using it to ensure economic and environmental sustainability. However, the social element has been neglected. The Ouroboros philosophy is the belief that social sustainability can be solved using circular thinking. So what is circular social sustainability in architecture? It is the use of utilized otherwise wasted resources for the betterment of the social environment. When looking at it from this direction it suddenly becomes closer to the pragmatic utopian architectural movement. Architects like BIG are great at utilizing spatial resources for social initiatives. As an example, the Copenhill project is a power plant in Copenhagen. Power plants as a typology have inbuilt requirements that caused wasted spatial resources. The size of these buildings usually causes the surrounding space to be unwelcome for the general populace. However, Copenhill utilizes its wasted resource, its size requirement, by making itself into a skiing hill. An activity that usually proves troublesome in Denmark, because of its geographic typology. Where this goes further is combining social circular sustainability and environmental circular sustainability. The future of architecture needs to adapt to the changing landscape concerning the environmental impact the building industry has on the world. However, we additionally need to rethink the social impact and resource usage we as architects use.

TIME FRAME AND MAXIMUM NUMBER OF USERS

The time schedule represents the timeframe of building use by the users, and together with the table showing the maximum number of users in the building, this data is expected to shape the design decisions in the most crowded areas as well as be used in the calculation of the operational energy demand and the requirements for mechanical ventilation rates.

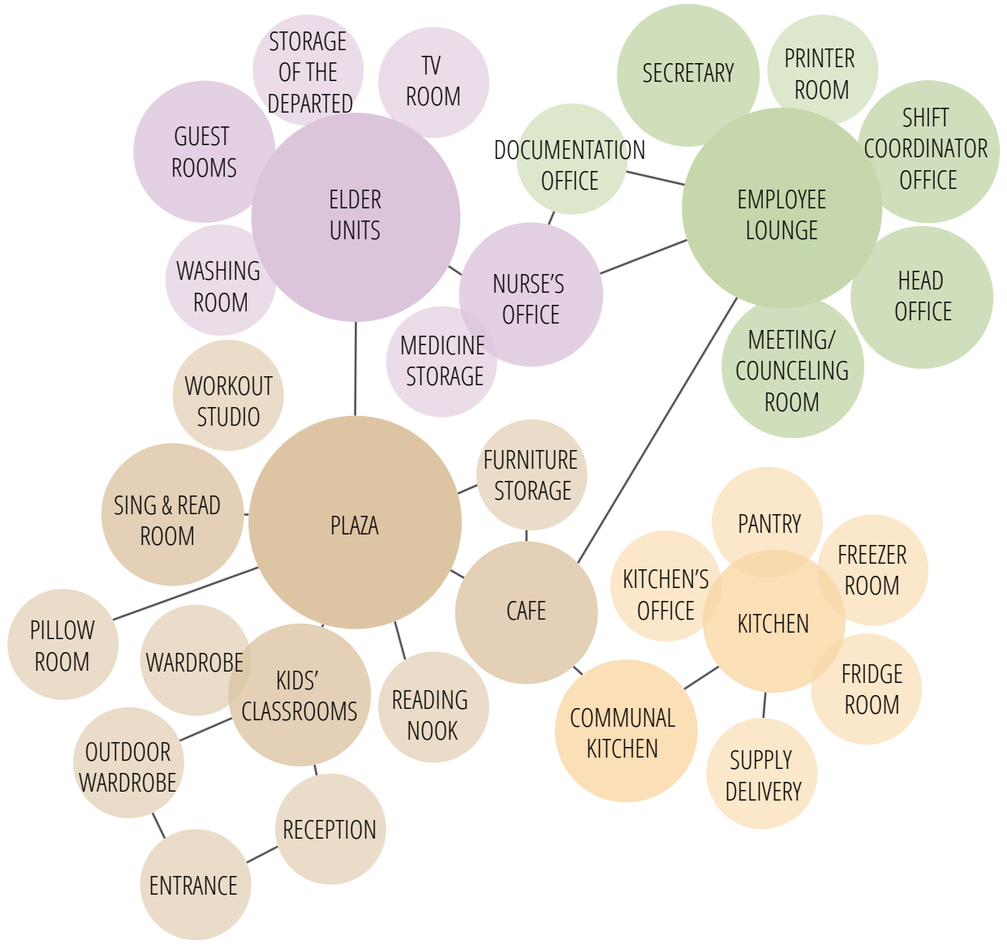
Type of user	Morning	Evening
Elder	11	11
Kid	100	0
Nurse	4	2
Kindergarten teacher	6	0
Cleaning staff	2	1
Kitchen staff	3	0
Receptionist	1	0
Secretary	1	0
Director	1	0
Guest	2	2
Total	133	16

Ill. 59. Maximum number of users in building

ROOM PROGRAM

Room	m^2	Light needs	Privacy
Elder apartments (12 x 45)	540	High natural	Private
Guest rooms (2 x 27)	54	High natural	Semi-private
Kids' group rooms (6 x 58)	348	High natural	Semi-private
Wardrobe by group room	60	Medium natural	Public
Wardrobe outdoor wear	62	Medium natural	Public
Cafe/restaurant	132	High natural	Public
Plaza	306	High natural	Public
Gym	95	High natural	Private
Library	160	High natural	Public
Reception and lounge	67	Medium natural	Public
Chaging room	18	None	Private
Nurse's office	12	Medium natural	Semi-private
Wind Catch	12	None	Public
Kitchen	78	Medium natural	Private
Kitchen pantry	4	None	Private
Communal kitchen	19	Medium natural	Public
Kitchen office	12	Medium natural	Private
Freezer room	5	None	Private
Refridgerator room	5	None	Private
General storage	27	None	Private
Furniture Storage	11	None	Private
Secretary	12	Medium natural	Semi-private
Shift coordinator's office	12	Medium natural	Semi-private
Employee lounge	118	High natural	Semi-private
Head office	12	Medium natural	Semi-private
Meeting / counceling room	50	Medium natural	Semi-private
Documentation office	12	None	Private
Music room	66	Medium natural	Public
TV room	23	Medium natural	Public
Storage of the departeds' belongings	13	None	Private
Pillow rooms	13	None	Public
Toilet children	45	None	Private
Handicap toilet	12	None	Private
Toilets in public space	20	None	Private
Washing room	18	None	Private
Cleaning room	21	None	Private
Technical room	39	None	Private

FUNCTION DIAGRAM



Ill. 60. Function diagram

Have kids and elders interact naturally, while maintaining the privacy of the elders

Create activity spaces where users naturally meet and interact

Spaces design for functions, while allowing for flexible options

Design for the different levels of intimacy

DESIGN CRITERIA

Design for Disassembly

Use reusable and low polluting materials

Create explorative spaces

VISION

Ouroboros, as a fundamentally circular building, implements the concept of circular thinking holistically, having it integrated into all aspects of the design, such as societal, spatial, and technical. It is a scheme which seeks to minimize resources and utilize wasted resources on a social, environmental, and economical level. It values the wellbeing of the users, and for this reason, it prioritizes the proper facilitation of their needs as well as their probable wishes. Ouroboros architecture is conscious of the social, environmental, and economical impact of the building and therefore considers its surrounding context. Ouroboros isn't an architectural style but a movement of rethinking the relationship between architecture and sustainable innovations. It uses the strengths and each of these disciplines to further the field of architecture. All of the above are made in respect to the past and the lessons we can harness from the architects and engineers before us on providing quality buildings, and concerning the future, ensuring that the Ouroboros can adapt to the future needs or even be transformed to facilitate new, unimaginable future needs, causing minimum environmental footprint.

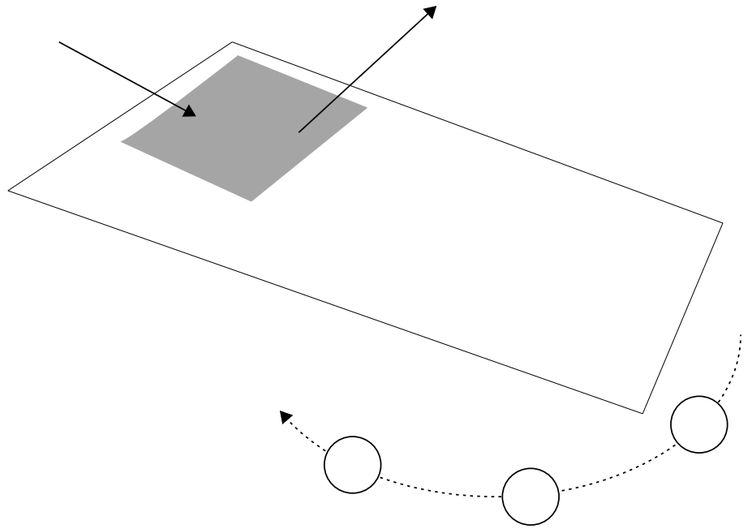
PRESENTATION

Concept
Masterplan
Floor plans
Facades
Sections
Unity
PLay plaza
Library
Cafe
Workout studio
Music room
Outdoor activities

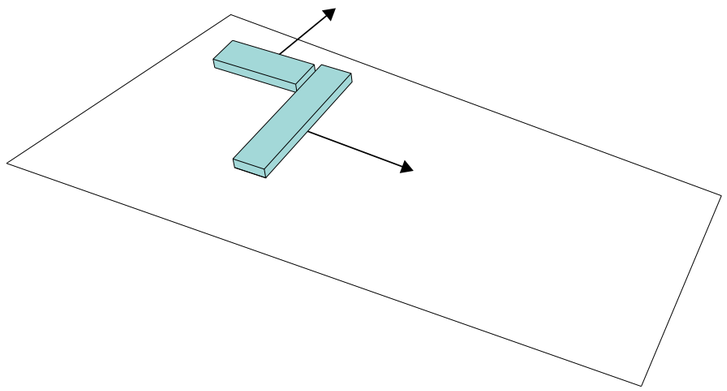
Apartments
Group rooms
Staff
Materials
Details
Wall panelling detail
Passive and active strategies
Indoor comfort
Life Cycle Assessment

The Ouroboros is a shared facility that houses 100 children and 11 elders. The facility allows the two groups to freely interact and play with one another. The building is situated just south of the new Frederiksbro city district in Hillerød. The building seamlessly blends the modernity of Fredriksbro with the traditional of the preexisting areas thereby creating a link between them. The Ouroboros is a circular piece of architecture that reuses the knowledge and experiences of the elders to teach and enrich the next generation. Additionally, the building is completely disassemblable and allows with ease to be transformed in the future.

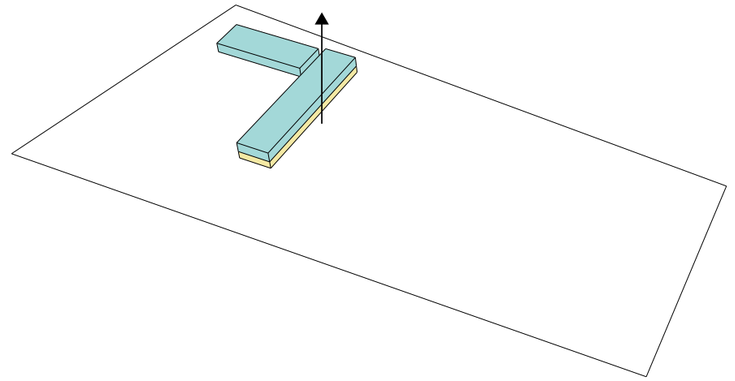
CONCEPT



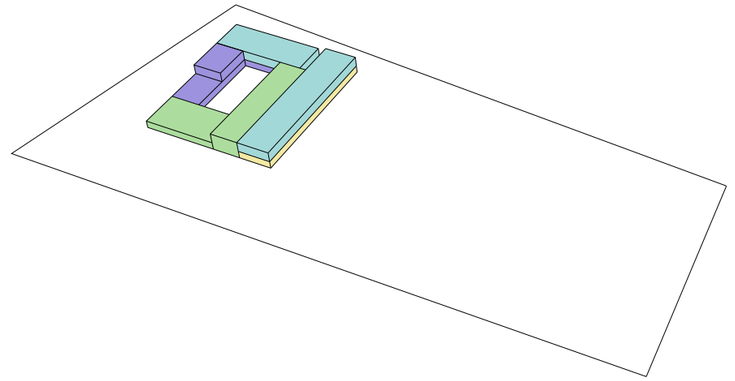
1. The building is placed on the northwestern corner of the site, to shield it from the western wind, create sunny outdoor areas in the morning to afternoon time, and build up against the new area Frederiksbro.



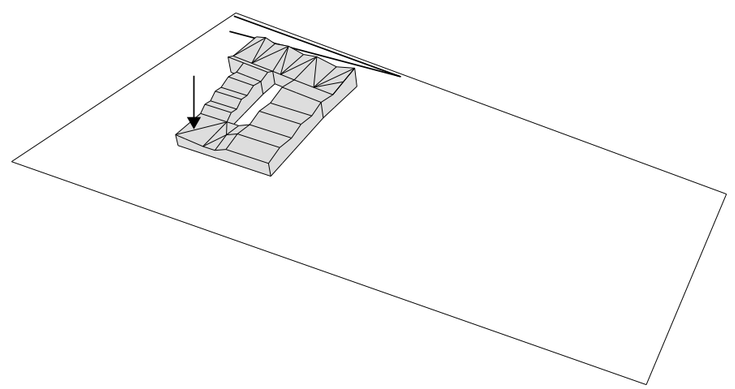
2. Place the elders' apartments towards the north and east. This ensures the elders are looking at activities at all times.



3. The elders are raised to create a defined border between the elders and children sections of the building. The kids' group room is placed under the elders' apartments facing east.

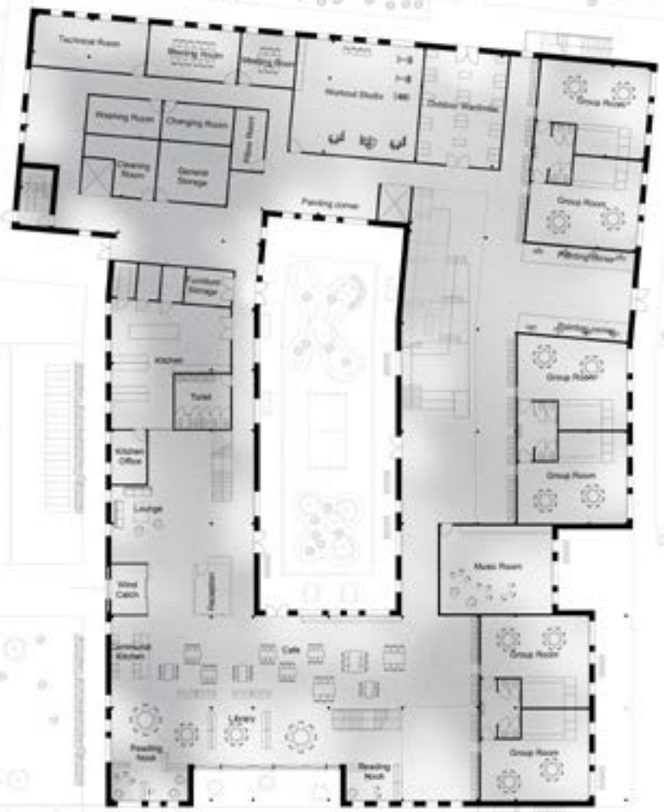


4. Activity areas are placed in the intersection of the elders and kids sections, and towards the south. The staff is placed to the west and north.

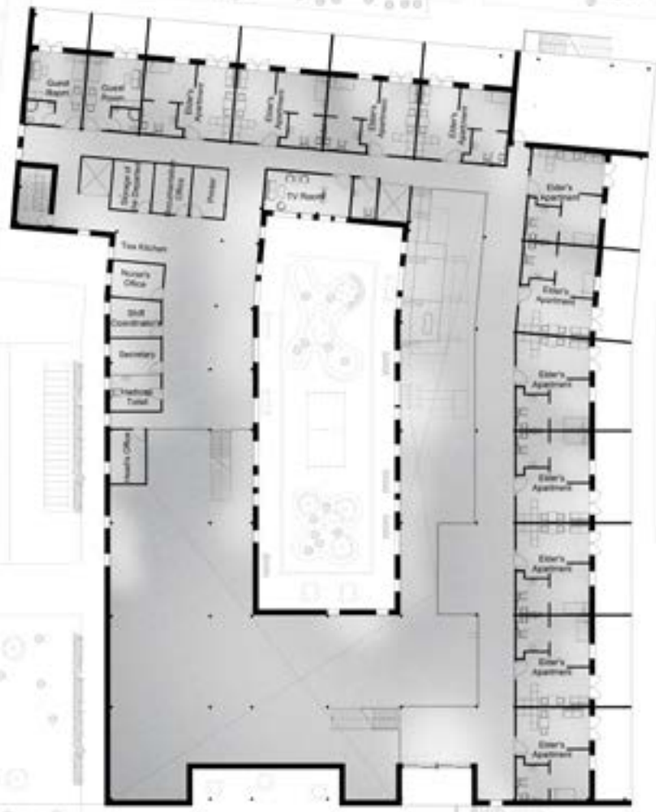


5. The northern end of the building is rotated to conform to the syntax of Frederiksbro. The roof is pitched and lowered towards the south to allow the sun to enter the inner courtyard.

Ill. 61. Masterplan - 1:1000



Ill. 62. Ground floor plan - 1:500



Ill. 63. Upper floor plan - 1:500

Ill. 64. Northern façade - 1 : 500

Ill. 65. Southern façade - 1 : 500

Ill. 66. Eastern façade - 1 : 500

Ill. 67. Western façade - 1 : 500

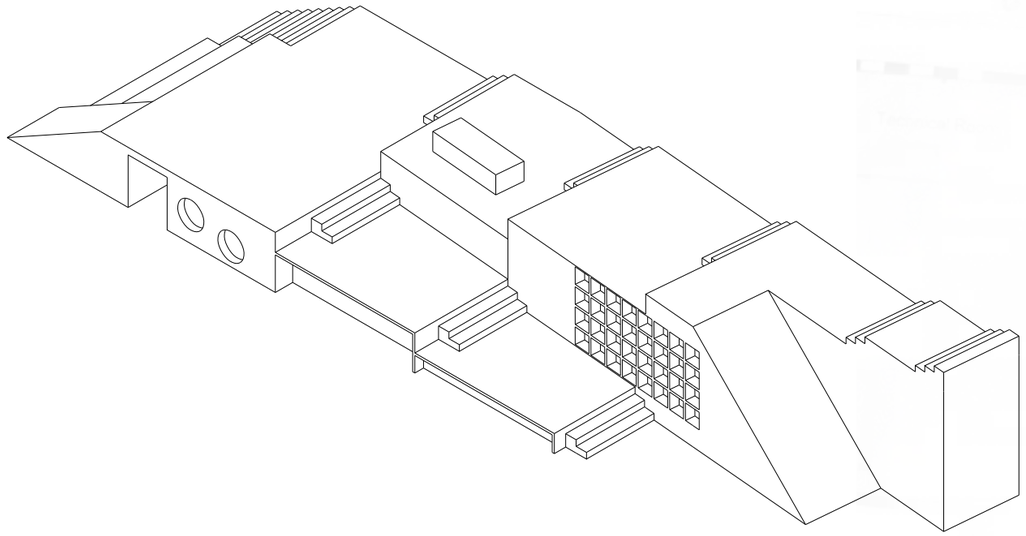
Ill. 68. Section AA - 1 : 500

Ill. 69. Section BB - 1 : 500

UNITY

Ouroboros to unify the elders and the kids while allowing the elder to recede into their private rooms. The project achieves this by placing the elders' apartment on top of the children's classroom. By connecting them with an open atrium in the activity spaces, the elders are drawn down towards the children while allowing them to remain passive observers on the first floor if they so wish. The human is attracted towards activity, so the elders will be drawn down towards the playing kids, allowing them to form bonds of friendship and gifting their knowledge and life experiences.

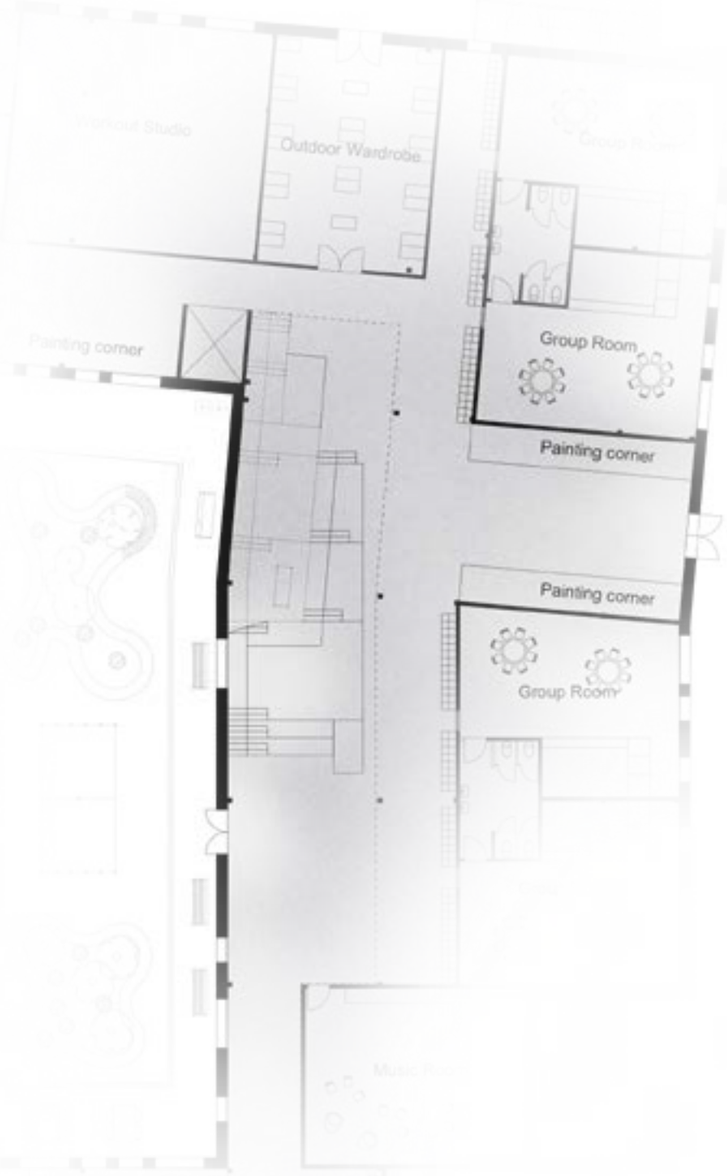
Ill. 70. Play plaza



Ill. 71. Play plaza isometric view

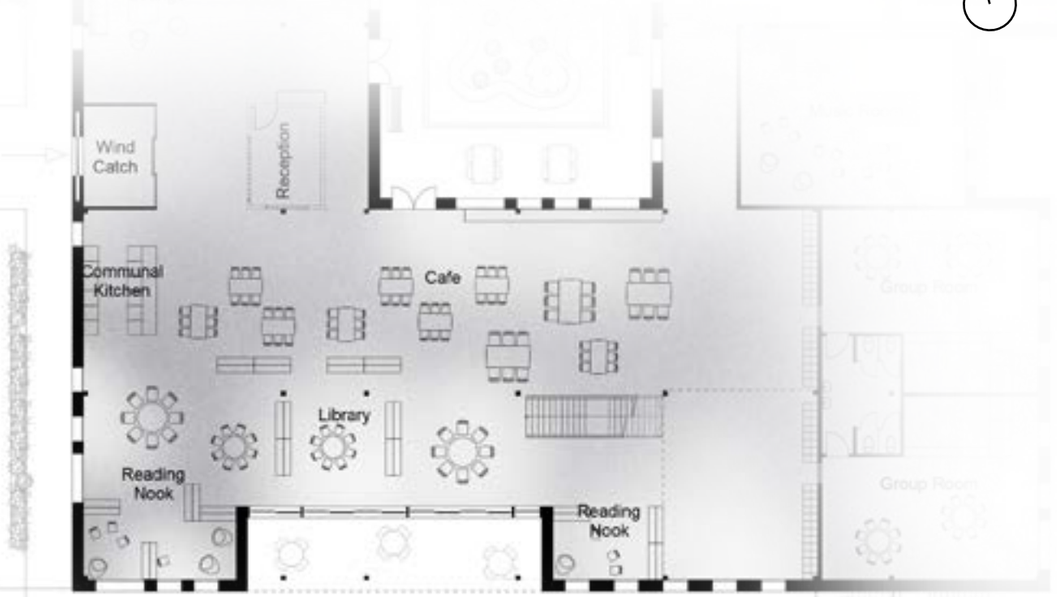
PLAY PLAZA

Play plaza is the heart of the facility. It combines a multitude of activities for kids and elders to attract them and encourage intergenerational interaction. It serves as an area for both active and passive involvement. It consists of several levels, connected through stairs and slides. The levels operate as areas where the kids and elders can play together, craft together, sit together and read to each other, or watch the surrounding area and on-going activities. Part of its vertical surface is equipped with shelves available for storing toys, books, possibly exhibiting crafts of the users, etc. On the vertical axis, there is also a climbing wall for the kids. The inner part of the play plaza is accessible to the kids through a crawl gap, to encourage exploration. The stairs of the structure reach the second floor, connecting further the two floors and reducing the perceived distance between kids and elders. Finally, there are many opportunities for bidirectional passive interaction between the users sitting in several viewpoints of the play plaza and the rest of the users within the indoor public space.



Ill. 72. Play plaza placement

Ill. 73. Southern activity area



Ill. 74. Southern activity area

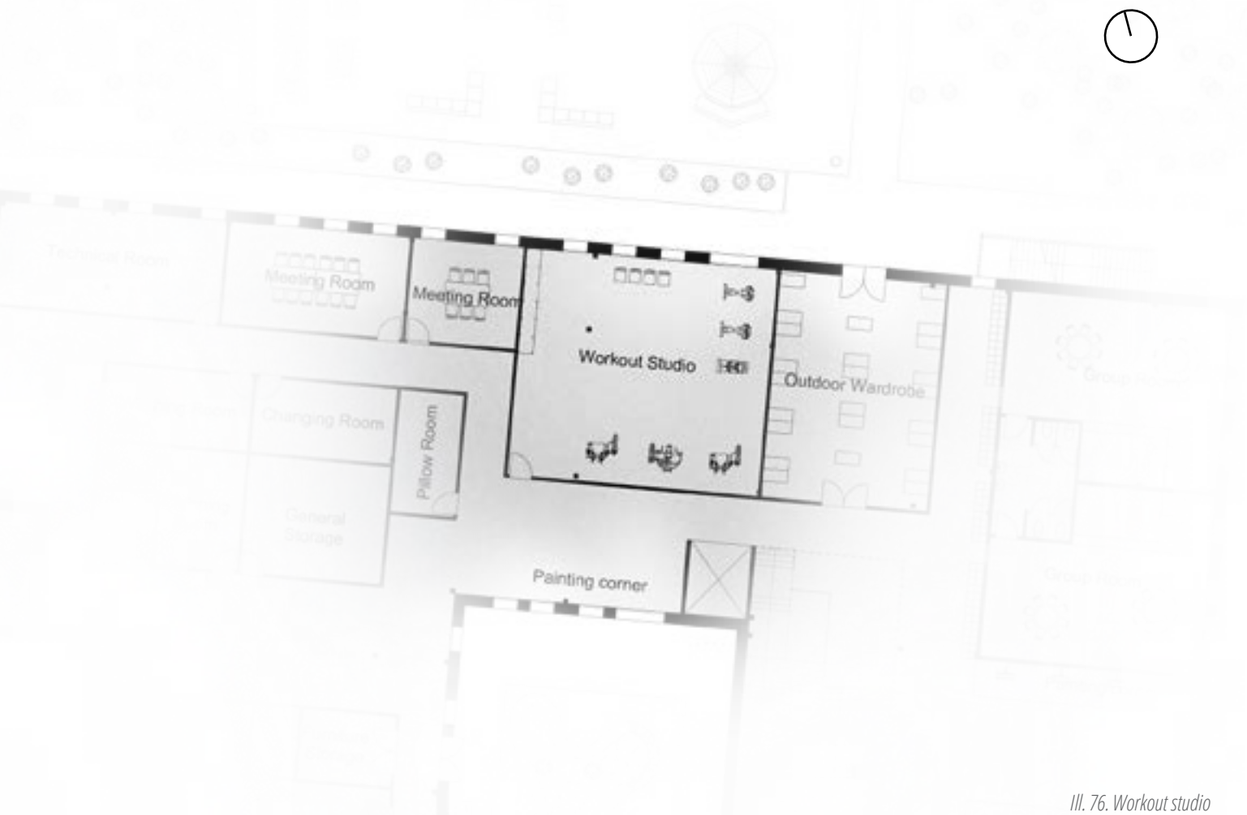
Ill. 75. Material section of library

LIBRARY

The library is where the kids and elders can partake in a few distinct activities. Firstly, the reading of books for one's enjoyment. The elders can go downstairs to read books. This quiet place is ideal for enjoying a book while giving them a chance to be social with other people. Additionally, the elders' presence will attract curious children sparking organic meetings and opportunities to engage in reading out loud. This would allow them to organically bond and develop friendships that would lead to further readings and storytelling opportunities. By doing this the kids are taught vital life lessons and the elder receives social validation. To allow for this the library is equipped with reading nooks with is additional sound absorption that increases the intelligibility of the spoken words. The library is additionally equipped with furnishings and tables for both kids and elders.

CAFE

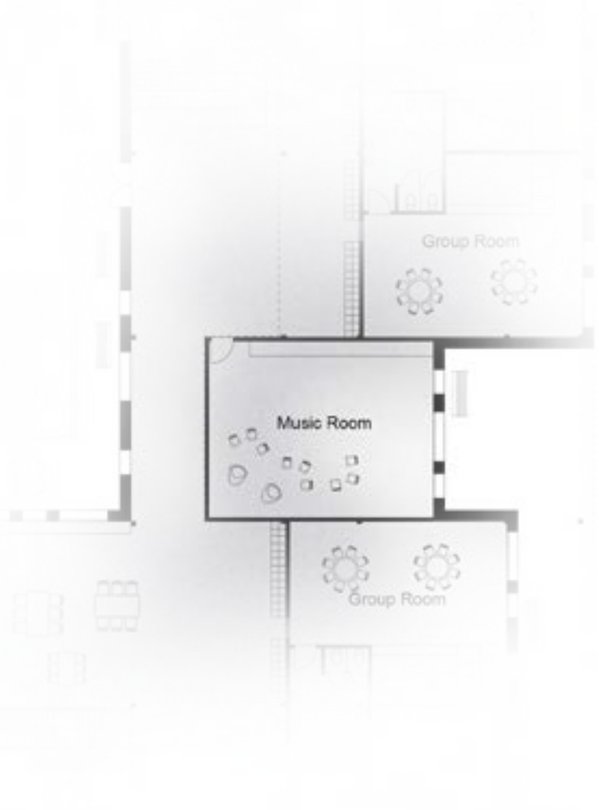
The cafe is an area vital in building bonds between kids and elders. The cafe includes chairs and tables built for the size of each group. These are placed so that the elders and kids sit close to each other. To unify them in this area a communal kitchen is placed. The communal kitchen is a planned activity where the kids and elders can jointly prepare some of the food for their lunch. This would allow the elders to teach the kids vital life skills. The communal kitchen is built so that the elders and kids stand on each side with a step for the kids to reach.



Ill. 76. Workout studio

WORKOUT STUDIO

The workout studio serves as a place for the elders and kids to aerobic and machine exercises. This is to maintain the elders' health. Additionally, the place allows the people of Ouroboros to partake in dancing and other physical activities. The allows the kids to develop advanced motor functions and for the elders to learn from the kids. The workout studio serves as a place for the elders and kids to aerobic and machine exercises. This is to maintain the elders' health. Additionally, the place allows the people of Ouroboros to partake in dancing and other physical activities. The allows the kids to develop advanced motor functions and for the elders to learn from the kids.



Ill. 77. Music room

MUSIC ROOM

The music room is a sound-proof room where the kids and elders can partake in the rhythmic and educational activity of music. The room is furnished with smaller and quiet instruments. The idea is that the elders, or a pedagog, play or teaches the kids a small amount of music. This will help the kids develop cognitive abilities and deepen their bond with the elders.

Ill. 78. Outdoor activities placement - 1 : 1000

OUTDOOR ACTIVITIES

As mentioned in the theory, users can benefit from getting in contact with nature, both mentally and functionally (Seo, 2006). For this reason, it has been preferred to limit the use of pavement for allowing ease of movement to the users with mobility issues and enhance the element of nature by enriching it with additional plants, such as flowers and trees. For the ease of the personnel to supervise the users, big bushes have been avoided, so that the users cannot remain out of sight, therefore all plants are below 0,90 m, as the average height of kids of 3 years old in Denmark is 0,96 m (Kløvgaard et al., 2018), or above 1,80 m.

The area is organized in two zones, which are defined by the use of nature and the type of intergenerational integration. The first zone is close to the building, where the intergenerational interaction is designed to be more active and nature facilitates the education of the users. In the second zone, the intergenerational interaction is designed to be passive and nature operates as a shelter, protecting the users from wind, sun, and external disturbance.

The active zone is organized in a way to combine the typical playground equipment with sitting space to encourage the users to get together and interact, while the passive zone provides opportunities for passive interaction or even isolation. There are several options for sitting within the area, both sheltered and exposed to the weather, to fit all needs. The activities concerning the kids are always visually accessible from the sitting spaces for adults, both for the ease of supervision and to provide an interesting view to the seated users, as Jan Gehl suggests.

ACTIVITIES

Nature gets involved in educational activities as the playground is equipped with greenhouses and flower beds, which can facilitate the intergenerational activity of gardening or growing food together. Such activities will educate the users about the nature of nature itself, therefore enhance the curiosity of kids, while providing calmness to all users. Edible plants that are commonly grown in Denmark in greenhouses concern tomatoes, cucumbers, lettuces, mushrooms, and so on, while squashes and strawberries might also be grown in the beds exposed to the weather (L., Gadtke, n.d). Commonly grown flowers that flourish in the local environment are Danish daisies, gladiolas, roses, red clovers, and so on. The process of growing food is also expected to bring the kids in contact with insects, such as ants and snails, and allow their observation and interaction, which, according to Dudek (Dudek, 2015) should be encouraged when striving to create an educational outdoor environment.

Another expectation is for the users to use their grown food while cooking in the communal kitchen and to use the compost bins next to the greenhouses for waste appropriate for composting, which can later be used as soil in the greenhouses and outdoor flower beds. The matter that is appropriate for compost and should be available within the site includes cut grass, tree leaves, and vegetable food scraps, such as banana peels, avocado skins, and so on. The participation of the users in these activities is expected to educate them about the circular economy in a practical way and allow them to deeply understand the circle of life.
Other activities include sandboxes, swings, slides, and other playground equipment, as well as fields, while in these areas there are also toy and tool storage spaces. Close to the playground equipment there are placed machines for outdoor workout, for the elders to use. Additionally, there is a mini football field (27x37 m) designed for kids aged below 7 years old (Thesoccerstore.co.uk, 2013), surrounded by benches and flowers. Finally, at some distance from the group activities, there is a meditative labyrinth, paved through flowers. The labyrinth can be used by both kids and elders and either individually or in small groups, providing an opportunity for contact with nature, mobility, and calmness.

INNER COURTYARD

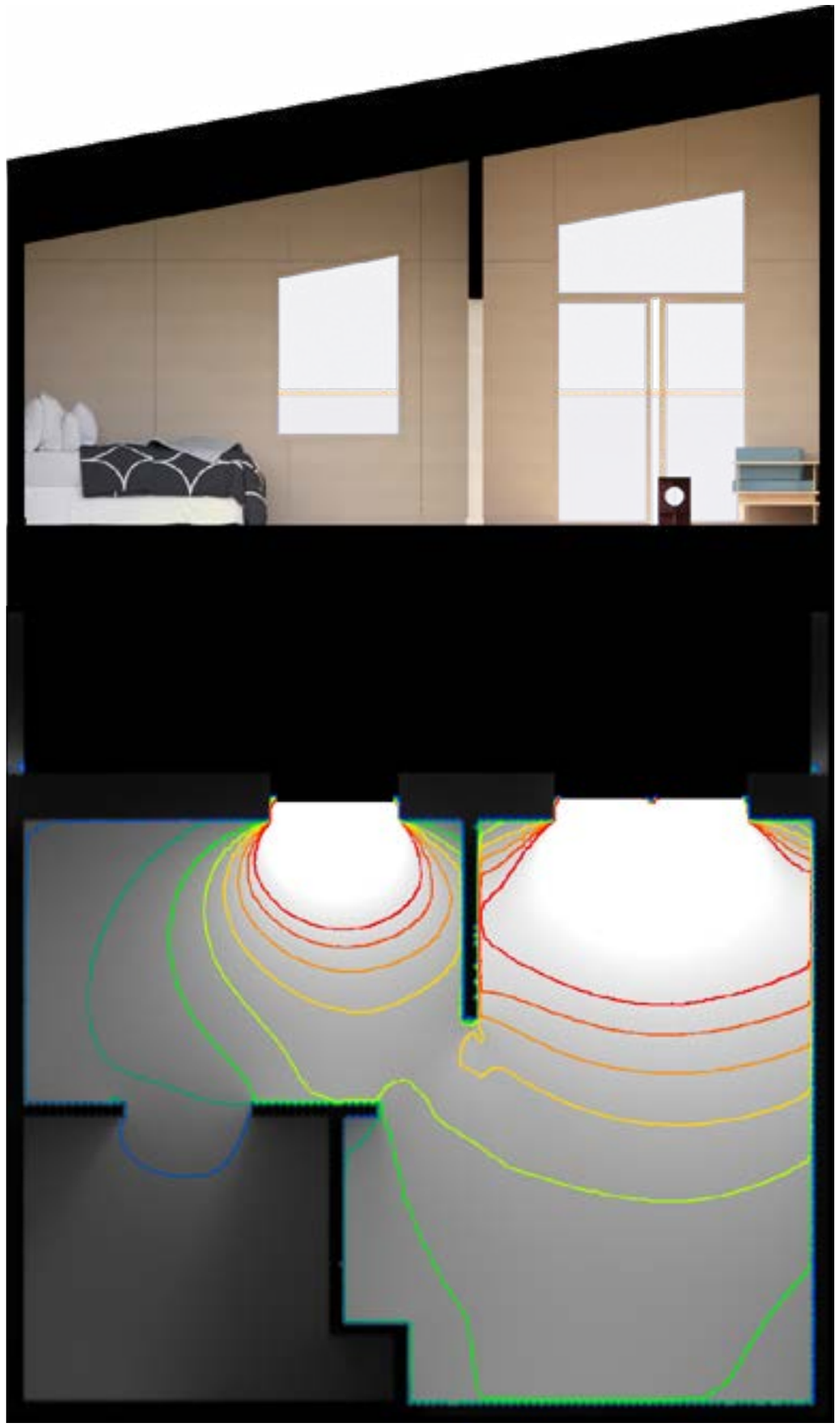
The challenge of designing the inner courtyard has been to provide a different experience from the outer yard. To achieve this, some of the principles of the healing garden design have been implemented, although this cannot be considered a healing garden. A variety of plants in shape and color has been preferred, while several sitting options are available placed intentionally to not face another sitting area directly and instead face towards the plants or some ongoing activity happening in the middle of the courtyard. Additionally, there is sufficient space for wheelchairs to move around without interruption. Perimetrically of the plants, there are paths paved by stones, which are expected to encourage the kids to play on them. For the free area in the middle, the team suggests that there could be a vinkingespil setup, where kids and elders can play together a local game, while the rest of the users can watch.

79. Elder's apartment

Ill. 80. Elder's apartment plan

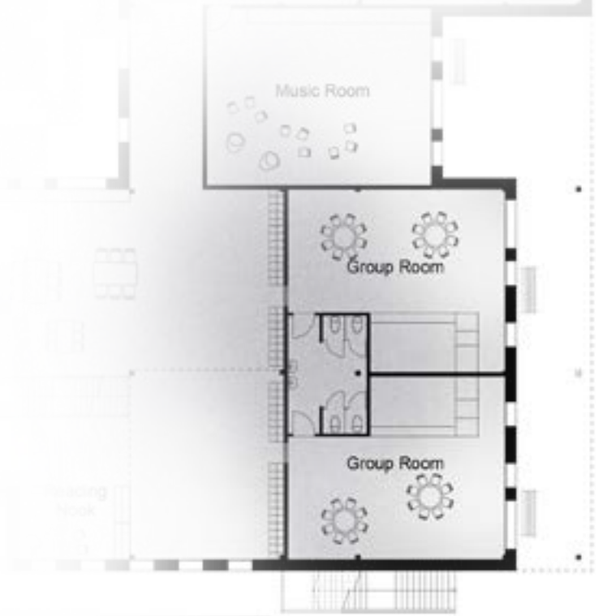
APARTMENTS

The apartments are a spacious and homely environment that the elders can change into their home. The apartment has a split design with a segregated living room and bedroom. This allows the elder to have guests while maintaining privacy. Furthermore, this split is supported by the shape of the roof. The private bedroom has a lower room height making it more intimate. The living room has a higher room height further emphasizing the difference between the two. The room overlooks, by an outdoor terrace, either the outdoor areas of Ouroboros or the recreational park area in Frederiksbro. This makes it so that the elders, even in the privacy of their quarters, are observing activities at all times. The apartment has a kitchen for the elder to maintain a degree of autonomy. The bathroom is accessed from the bedroom to allow the elder easy access during the night. The room is clad with wooden panels that emulate the feel cigar-box feel found in older danish houses.



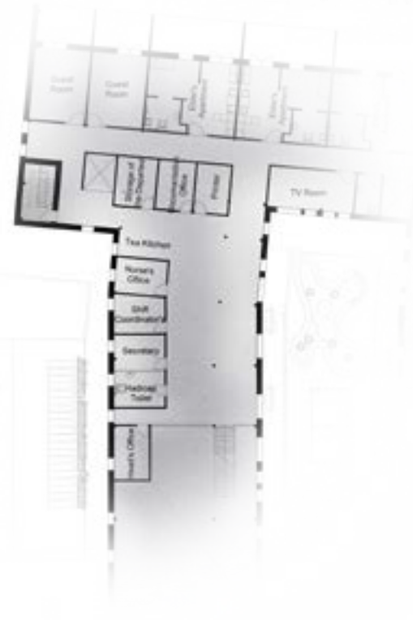
Ill. 81. Apartment material section

Ill. 82. Apartment daylight factor



Ill. 83. Group rooms

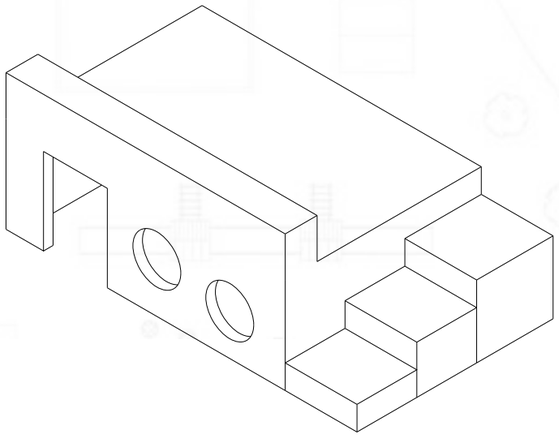
Ill. 85. Staff placement in ground floor



Ill. 86. Staff placement in upper floor

GROUP ROOMS

The group rooms are the organizational epicenter for the children of Ouroboros. Each morning all the kids are gathered and given instructions about the day's planned activities. Afterward, the kids are free to freely explore the rest of the facility. The room is furnished with tables for playing and a wooden construction in the corner, which the kids can play on top of and underneath. This allows the kids to explore within their group room, without incentivizing them not to enter the intergenerational space.



Ill. 84. Group room play construction

STAFF

The staff section is divided into two floors. The ground floor contains the functions that maintain the building, while the upper floor contains the administrative job. The staff section occupies the northwestern corner of the building ensuring that they get diffuse lighting most of the time. They have close contact with the southern activity areas and the elders' apartments, allowing them to quickly move into populated areas of the building for every day tasks and in case of emergencies.

MATERIALS

Ill. 87. Unknown Phtographer, u.d., Perforated acoustic panel, https://www.decustik.com/arxius/previes/99.jpg

Ill. 88. Unknown Phtographer, u.d., Clay wall finish, https://clay-works.com/?gallery=the-wave-bristol

Ill. 89. Unknown Phtographer, n.d, Carpet flooring, https://www.family-handyman.com/wp-content/uploads/2017/06/FH07DJA_CARSQR_01-2-e1521058722305.jpg

Ill. 90. Unknown Phtographer, 2019, Prefabricated seaweed thatched panel (Larsen K.), https://materialdistrict.com/article/prefabricated-seaweed-thatched-panels/prefabricated-seaweed-thatched-panels-materialdistrict-3/?fbclid=IwAR06RfC55kaVh6tdfrjXr9_hqx8ggt5u-ENBkufFVk7pDVPT2owW6VQhOUjc

Ill. 93. Unknown Phtographer, n.d, Vertically placed wooden lamellas, https://i.pinimg.com/originals/51/07/75/5107754f0b12d7bf1e0f8e4db1d1d0f8.jpg

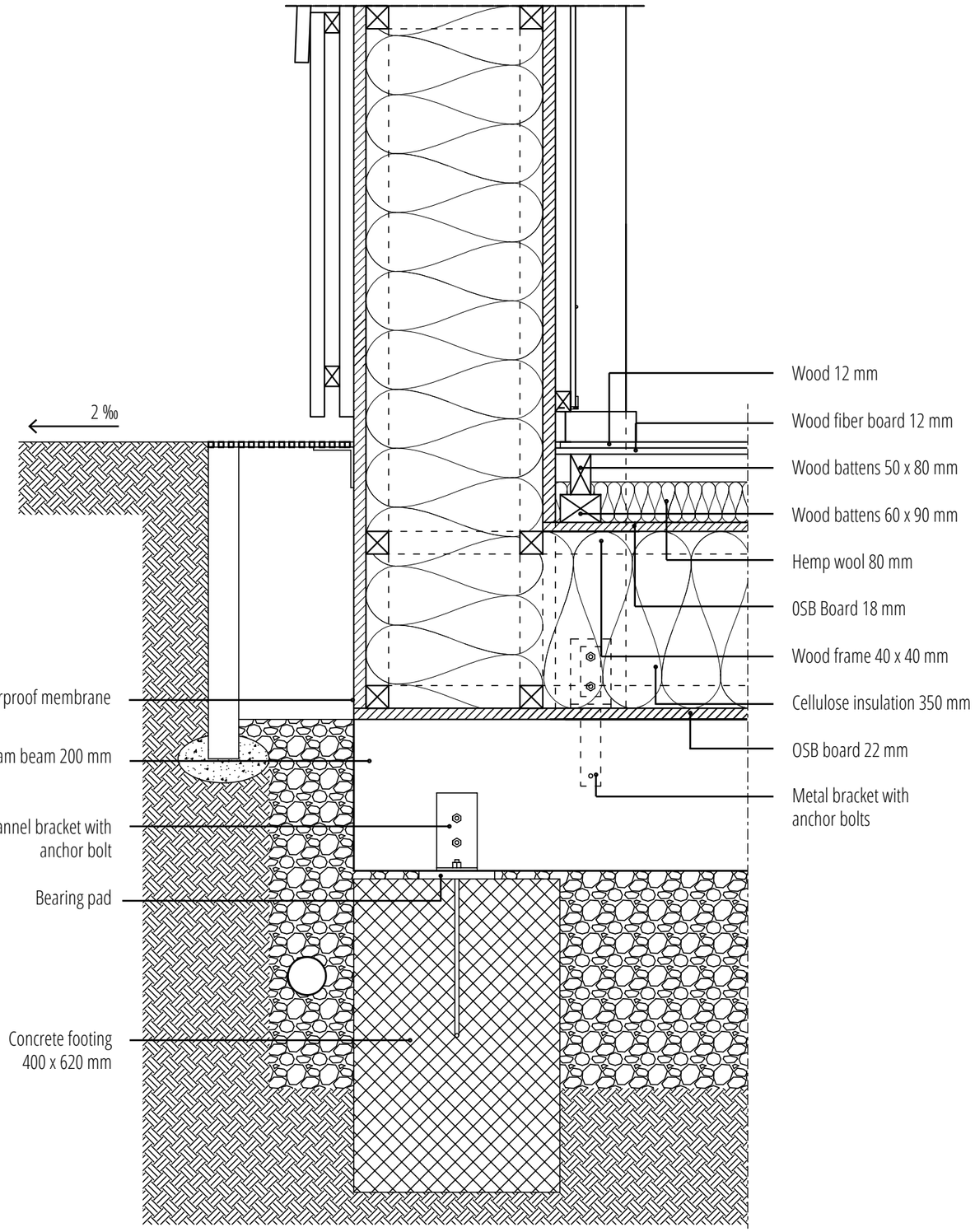
Ill. 91. Unknown Phtographer, 2011, Plywood interior wall finish, https://archinect.com/forum/thread/115304831/exposed-plywood-wall-finish

Ill. 92. Unknown Phtographer, n.d, Linoleum flooring, http://www.home-designing.com/grey-and-white-kitchens-design-ideas

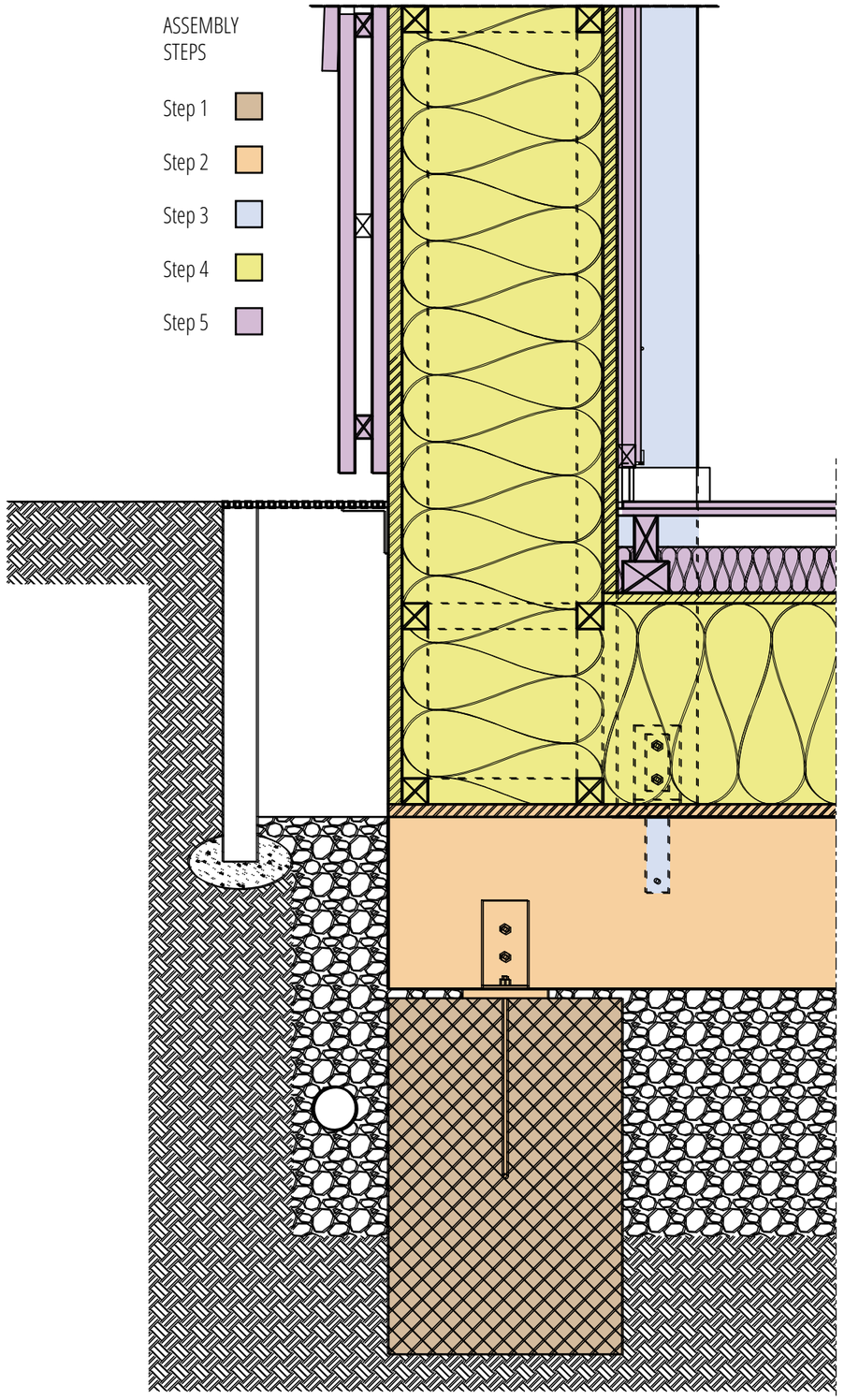
The building is mainly cladded withf natural materials, of no or low emitting pollution. The interior part has on the walls clay and plywood panels, the floor has wood, linoleum, and carpet, and the ceiling has clay and plywood panels and wooden lamellas. Clay is applied in a form of a rough texture and creates a feeling of connection to nature, while the plywood panels are both perforated and unperforated, for increased sound absorbance in critical areas, such as the music room and reading nooks. The floor is mostly linoleum, as it is very easily cleaned, which is important for such a facility, however, the floor in the apartments is wooden, and in the reading nooks is carpet, as we expect that the kids will prefer laying down. The ceilings in the majority are coated with clay panels, while the café/library area has a ceiling of wooden lamellas, and the apartments have plywood panels for ceiling finish. The essence of the materials in the apartments resembles that of a cozy wooden cabin, the reading nooks have a cozy yet more playful material palette, and the rest of the building has an inviting atmosphere while being easy to maintain. Externally, the building is cladded on its walls with wooden lamellas and on its roof with seaweed panels, while also the PV panels are integrated into the roof. Wood provides this warmness and connection to nature, and this is the reason it has also been used for the handrails of the building. Seaweed is locally available and has been part of the Nordic building materials palette in the past, therefore carries some cultural aspects. This contemporary form of it being produced in panels, in a way communicates the message of cultural recycling, as this old material has been processed to match contemporary needs, such as for it to be easily disassembled. Finally, it should be noted that all the materials have been used in earthy tones, such as beige, light brown, and light gray.

DETAILS

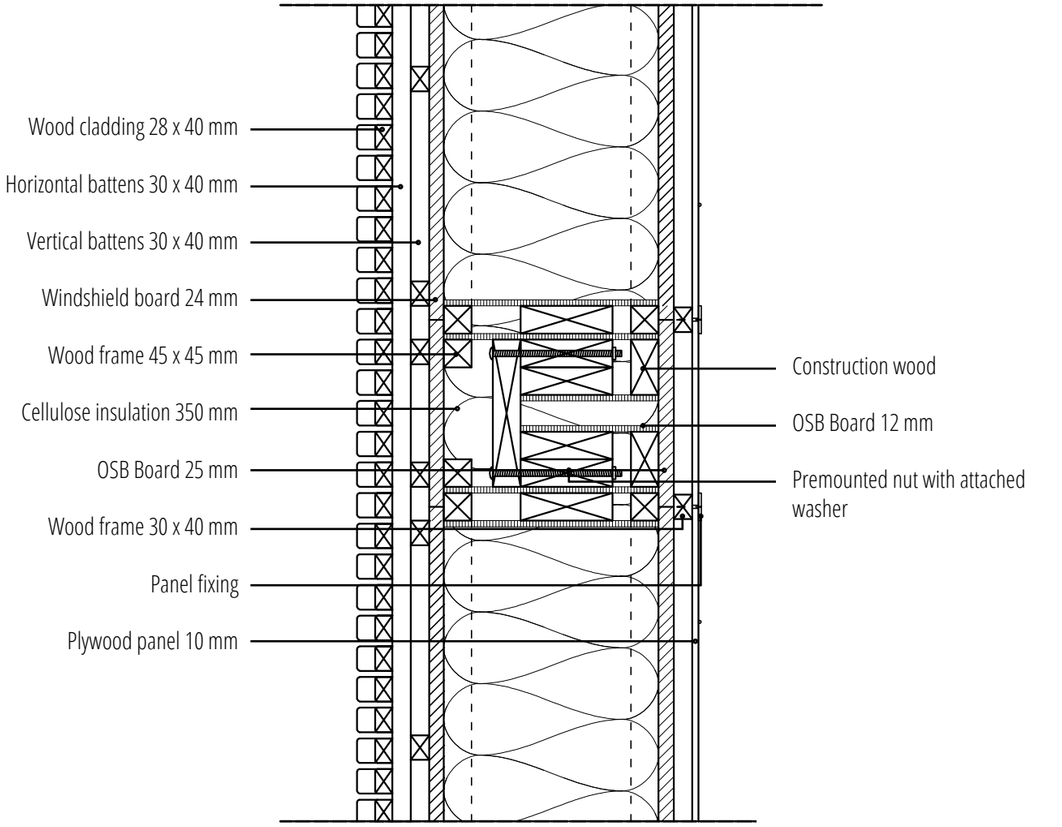
The design of the details focuses on showing how the DfD strategy changes the standard building process. The details have been developed under the guidelines of 3XN (3XN, 2019) for circular buildings. Every second page includes the assembly steps of the critical parts of each detail, which, followed in reverse, form the disassembly steps. The vast majority of the used materials are natural. The final detail shows in 3D our strategy for fixing the interior wall panels. As using panels has been thought of making sense into the DfD context, it was decided that all interior walls should be covered in panels fixed in a wooden frame, for us to have additional sound insulation in the apartments, music room, and reading nooks, without creating walls of different thicknesses. Additionally, this design will allow the users to fill in with additional insulation, e.g. sound insulation, for the case they feel that it is required in different or additional areas. For clay to follow the concept, it is suggested that it can be applied and dried on clay boards and be fixed as the plywood panels.



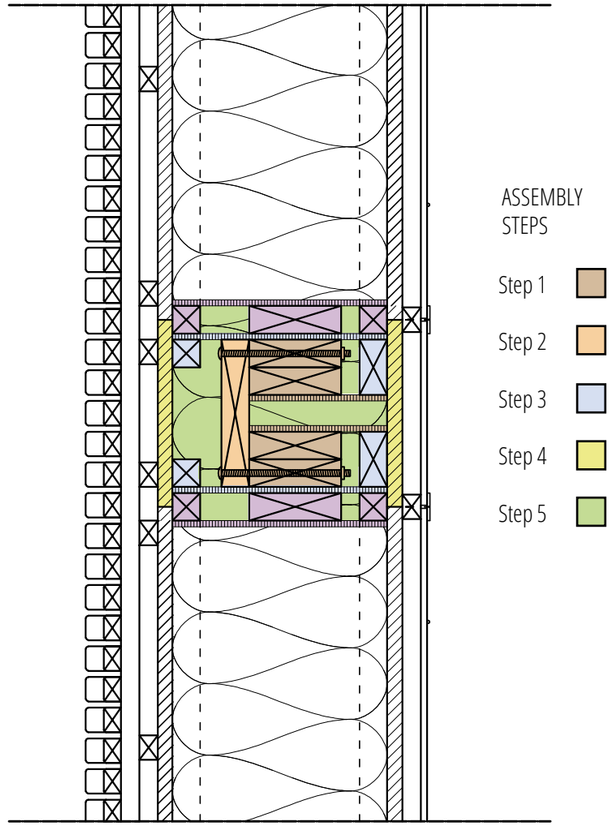
Ill. 94. Foundation detail - 1 : 10



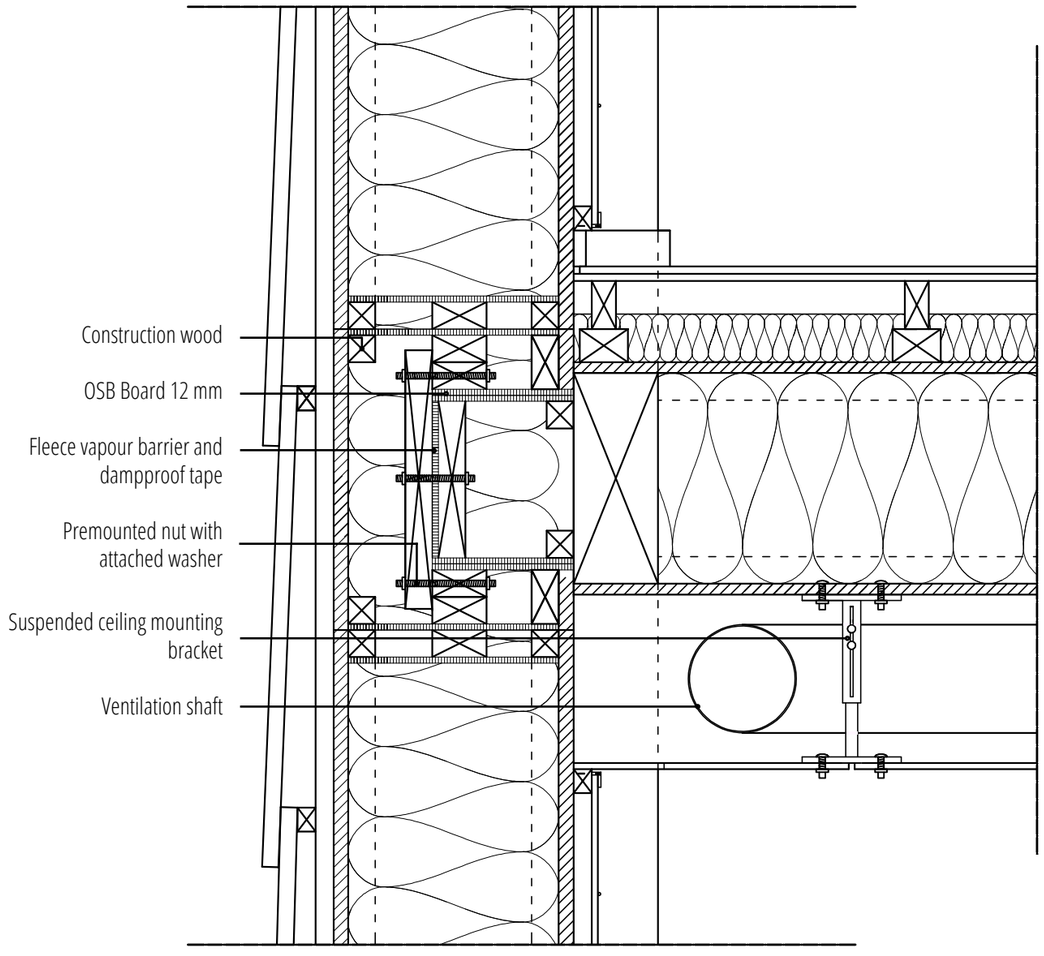
Ill. 95. Foundation detail - Assembly steps - 1 : 10



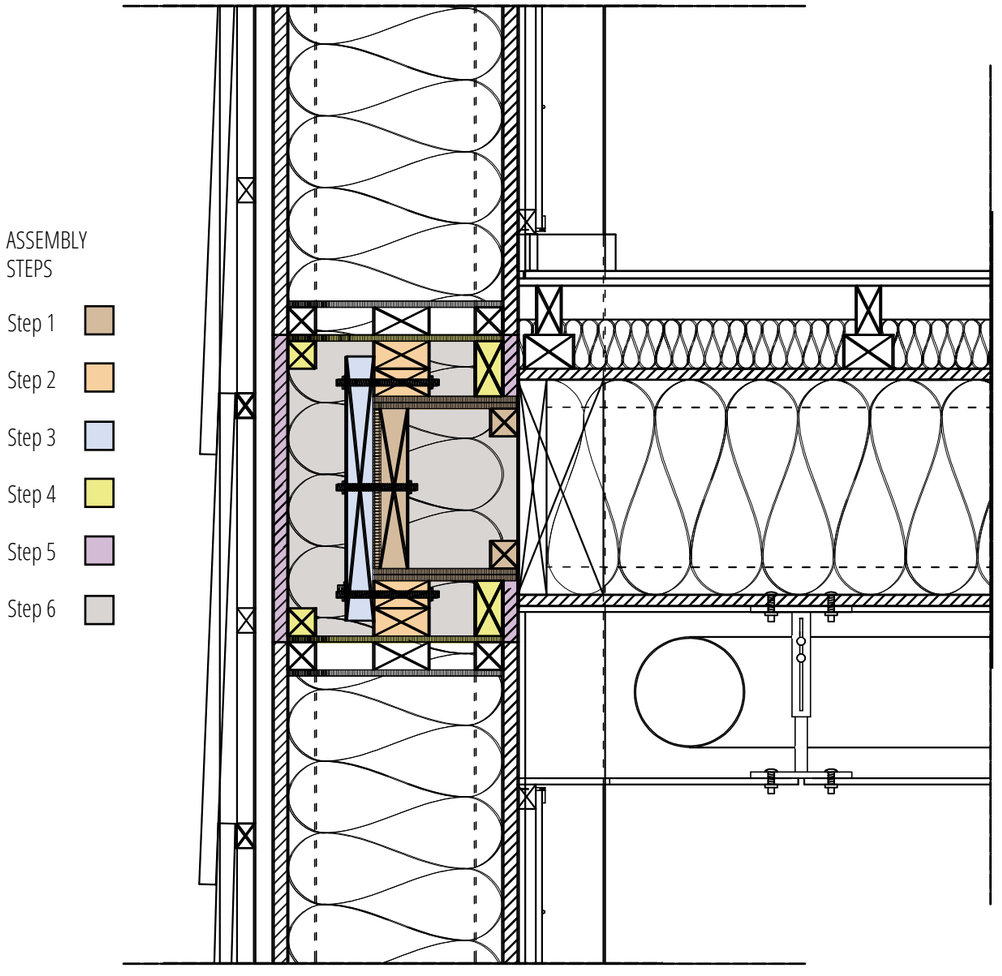
Ill. 96. Horizontal detail - Wall to wall connection - 1 : 10



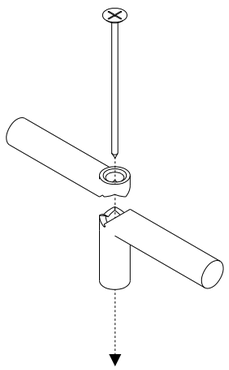
Ill. 97. Horizontal detail - Wall to wall connection - Assembly steps - 1 : 10

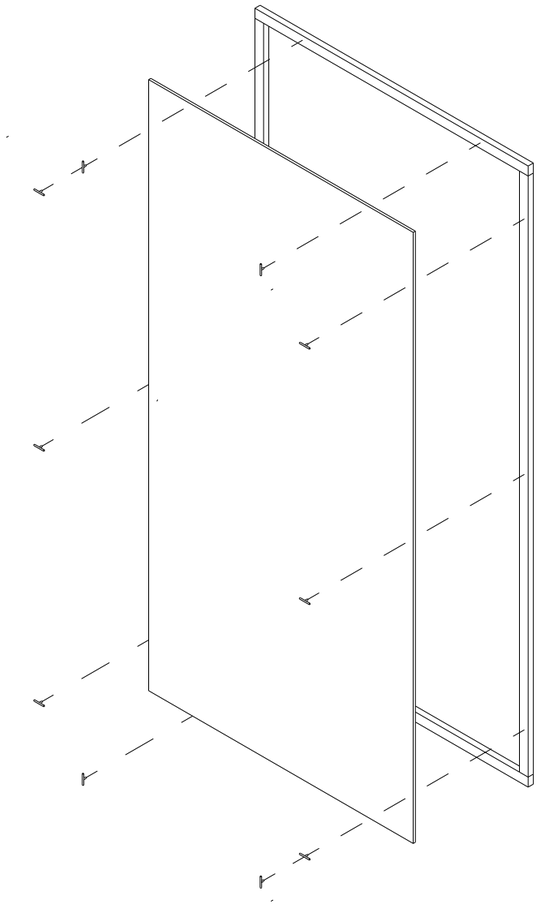


Ill. 98. Vertical detail - Wall to slab connection - 1 : 10



Ill. 99. Vertical detail - Wall to slab connection - Assembly steps - 1 : 10





Ill. 100. Wall panelling detail

INTERIOR FINISH DETAIL

This solution for the interior finish provides flexibility regarding easy inspection, maintenance, and replacement of the components of the building envelope. Additionally, it allows the users to rearrange the panels according to future needs. Lastly, it communicates the building's ability to be disassembled to all users.

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
95,6	0,0	95,6
Total energy requirement		24,6

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
71,7	0,0	71,7
Total energy requirement		24,6

Energy frame BR 2018

Without supplement	Supplement for special conditions	Total energy frame
41,3	0,0	41,3
Total energy requirement		24,6

Energy frame low energy

Without supplement	Supplement for special conditions	Total energy frame
33,0	0,0	33,0
Total energy requirement		24,6

Contribution to energy requirement

Heat	17,8
El. for operation of bulding	5,0
Excessive in rooms	0,0

Net requirement

Room heating	12,4
Domestic hot water	5,5
Cooling	0,0

Selected electricity requirements

Lighting	1,7
Heating of rooms	0,0
Heating of DHW	0,3
Heat pump	0,0
Ventilators	3,0
Pumps	0,3

Heat loss from installations

Room heating	0,0
Domestic hot water	0,2

Output from special sources

Solar heat	0,0
Heat pump	0,0

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
95,6	0,0	95,6
Total energy requirement		-0,4

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
71,7	0,0	71,7
Total energy requirement		-0,4

Energy frame BR 2018

Without supplement	Supplement for special conditions	Total energy frame
41,3	0,0	41,3
Total energy requirement		-0,4

Energy frame low energy

Without supplement	Supplement for special conditions	Total energy frame
33,0	0,0	33,0
Total energy requirement		-0,4

Contribution to energy requirement

Heat	17,8
El. for operation of bulding	-8,2
Excessive in rooms	0,0

Net requirement

Room heating	12,4
Domestic hot water	5,5
Cooling	0,0

Selected electricity requirements

Lighting	1,7
Heating of rooms	0,0
Heating of DHW	0,3
Heat pump	0,0
Ventilators	3,0
Pumps	0,3

Heat loss from installations

Room heating	0,0
Domestic hot water	0,2

Output from special sources

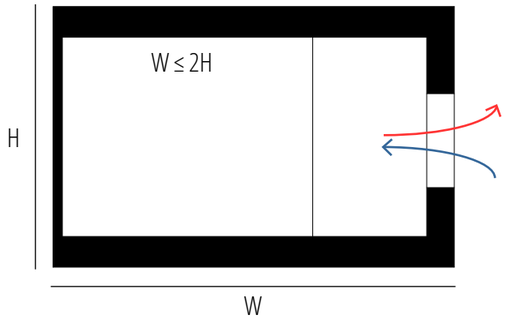
Solar heat	0,0
Heat pump	0,0

Ill. 101. Be18 results

PASSIVE AND ACTIVE STRATEGIES

The first step towards creating a building of low operational energy demand was striving for a compact building design that would result in a comparatively small envelope to reduce the heat transmission through the building envelope. The roof shape has also changed several times in order to participate in the reduction of the building envelope while creating a more home-like environment indoors. Additionally, the building has been elongated to reduce its exposure towards the North and increase the area facing the East, which is ideal for placing the morning activities. Following, the focus was given to creating a building envelope of low thermal transmittance. The placement of the openings was also important in allowing sufficient daylight into all areas while avoiding a big indoor temperature range. The placement of the windows also enabled one-sided and stack natural ventilation, as the windows and doors can be opened. Moreover, the courtyard allowed all areas to have cross ventilation when this is wanted, as well as daylight sufficiency. The main ways to provide shadowing for the openings have been using overhangs and designing window cases that are placed according to the orientation of each window exposed to the weather conditions, while deciduous trees have been additionally added alongside the southern façade. The implementation of these strategies has allowed the building to have an operational energy demand of 24,6 kWh/m^{2}year, falling within the energy frame Low Energy.

The active strategies concern the provision of energy and water to the building. Regarding the operational energy, the building is sufficient through installing photovoltaic panels on part of its roof facing towards the South, resulting in it becoming Zero Energy (-0,4 kWh/m2year). Additionally, concerning the white-water demand, there has been installed a roof catchment system to collect all the available rainwater falling on the roof and reusing it for toilet flushing and irrigation. This strategy is providing sufficient greywater for toilet use, leaving 959413,5 Lt available for irrigation, and therefore reduces the white-water demand.



Ill. 102. Single -sided ventilation in apartments

Ill. 103. Cross ventilation in lounge areas

INDOOR COMFORT

Natural ventilation

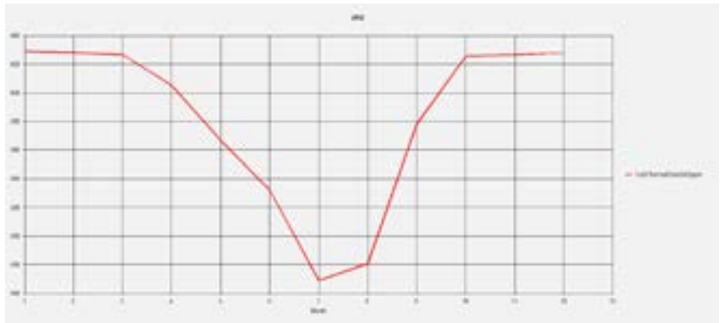
Natural ventilation should result in an improved atmospheric and thermal quality while reducing the need for mechanical ventilation and therefore reducing the operational energy demand. Additionally, it has been discussed from the beginning that the users, especially the adult ones, would prefer to have manual control of the natural ventilation, as this would add to their sense of ownership.

The public indoor areas of the building benefit from the courtyard as it enables cross ventilation. Cross ventilation works when two openings from the opposite sides are open and the distance between them is smaller or equal to five times the height (Thegreenage.co.uk). On the western side of the public area (entrance and lounge), depth equals 11,60 m while the mean height is 5,00 m and on the southern side of the building (café and library), depth equals 12,40 m while the mean height is 4,05 m.

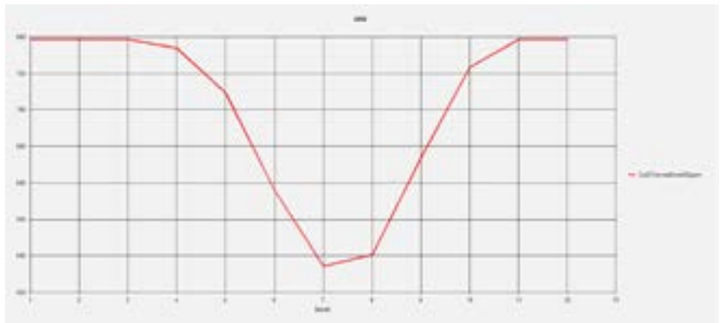
- Entrance and lounge: W ≤ 5 H => 11,6 < 5 x 5 => 11,6 < 25 true
- Café and library: W ≤ 5 H => 12,4 < 5 x 4,05 => 12,4 < 20,25 true

For the elder apartments, it is ensured that one-sided ventilation can work, as what is required is the depth of the area is smaller or equal to two times the height. The depth of the elder apartments is 5,95 m and the mean height is 3,25.

- W ≤ 2 H => 5,95 < 2 x 3,25 => 5,95 < 6,5 true



Ill. 104. CO2 levels in kids' group room



Ill. 105. CO2 levels in elder's apartment

ATMOSPHERIC COMFORT

The atmospheric comfort is of paramount importance when designing facilities like this. A lot of kids are gathered in one place, and elders benefit greatly from the clean air. The concentration of carbon dioxide (CO2) and sensory pollution (olf) have been calculated for one of the kids' group rooms and one of the apartments. To ensure the comfort simulations have been made in BSim. We estimate that approximately 65% of children will be in the group room from 7-17. Additionally, we estimate that the elder is spending all their in their apartment, with another person visiting them 3 times daily. We use these numbers because we consider them to be the worst-case scenarios for user occupancy of these rooms. The group room has a mean average of 583 ppm CO2, and the elder's apartment has a mean average of 705 ppm CO2. The elder's higher ppm is likely coursed by the low air change rate in the simulations.

THERMAL COMFORT

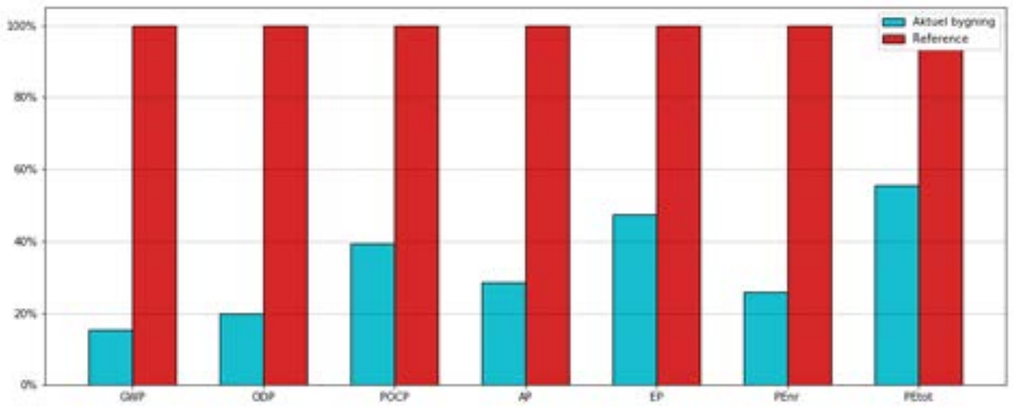
When occupying a particular space the thermal comfort is of particular importance. So the same spaces mentioned above were simulated in concern to their thermal properties. A group room and apartment in the eastern façade closest to the north were chosen. These zones, which were deemed the hotspots, had no trouble with their thermal comfort. The apartment has 51 hours above 26oC and 7 above 27oC. The group was hotter although beneath the maximum allotted thermal discomfort. With 103 hours above 26oC and 36 hours above 27oC.

VISUAL COMFORT

Daylight sufficiency has been achieved by ensuring that all critical areas, meaning the apartments and the kids' group room that is most shadowed, have a daylight factor above 2%. Additionally, it has been achieved that all users have visual access to nature, regardless of where they sit in the building, out of all the designed areas for activities for kids, elders, or both.

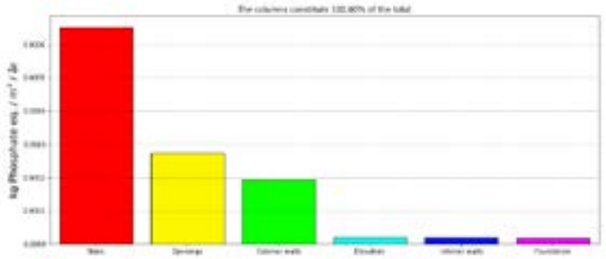
ACOUSTIC COMFORT

Acoustic comfort is ensured by adding sound absorbant hemp insulation on all slabs and in the walls of all critical areas, that being considered the music room, the reading nooks, and the walls between the apartments. Additionally, in the reading nooks there have been added carpet flooring and perforated acoustic plywood panels.

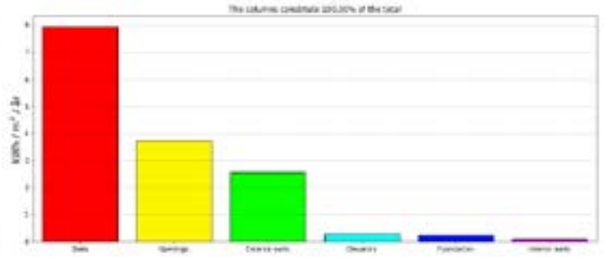


	GWP	ODP	POCP	AP	EP	PEnr	PEtot
First scenario	15,15	19,84	39,46	28,3	47,48	25,59	55,59
DGNB	100	100	100	100	100	100	100

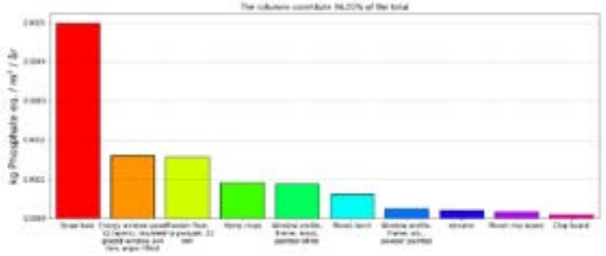
Ill. 106. Comparison of environmental impact between first material scenario and DGNB reference



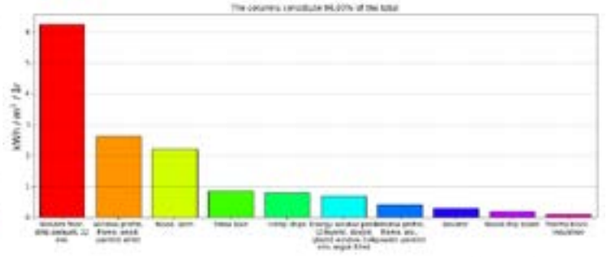
Ill. 108. Hotspot: Building components (EP)



Ill. 109. Hotspot: Building components (PEtot)



Ill. 110. Hotspot: Building products (EP)



Ill. 111. Hotspot: Building products (PEtot)

LIFE CYCLE ASSESSMENT

LCA

The building has been from the early stages visualized as a building of low-polluting, natural and/or recycled building materials. The main factors that have influenced this decision have been the improvement of the indoor climate for the users and the need for the materials to be circular, meaning that they either have multiple options for future use after their first life cycle, or they are products of recycling, while the process of recycling creates low pollution itself.

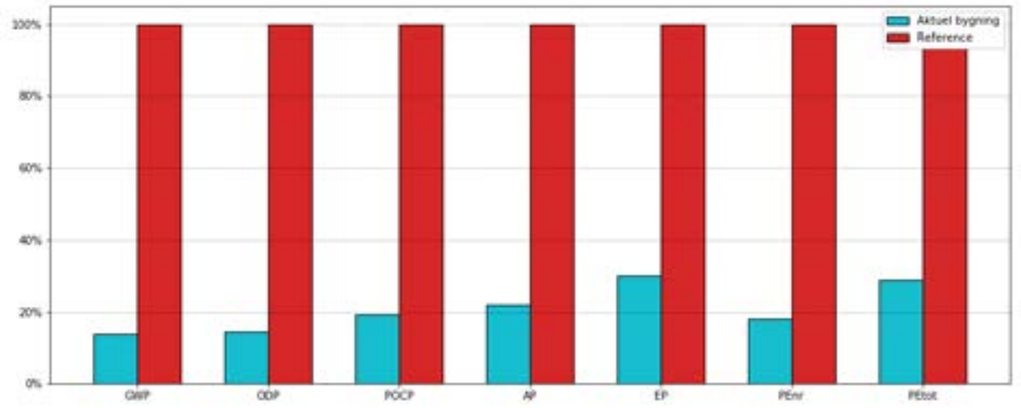
The core materials of the initial material scenario have structural wood and straw bale. The exterior and interior coatings have been calculated as being out of wood. The LCA analysis in this case has shown that the building already performs excellent in comparison to the DGNB framework, regarding its environmental footprint. However, the comparison between the existing scenario and the DGNB reference shows that the factor of Eutrophication (EP) and Primary energy total (PEtot) are the highest ones and therefore could be lowered. The hotspot analysis shows that the use of straw bale in the slabs is the main reason for the level of Eutrophication, while PEtot is relevantly high because of the use of wood for all the slab coating.

Based on this information, a second material scenario has been created, where straw bale has been replaced with cellulose, which is a product resulted by recycling paper and therefore has high negative environmental impact in its Product Stage (A1-A3). Additionally, in all areas apart from the elder apartments, the wooden coatings have been replaced on the ceilings by clay plaster, which is locally available while being easy to install, uninstall, and reuse, and for the floors, the wood has been replaced by linoleum, which is more durable, easy to clean, and requires lower maintenance.

Wood as and interior coating has remained existing in the finish of the indoor surfaces of the elder apartments. Other elements, such as the structural wood, windows, exterior coatings, elevators, screws, and foundation have also remained the same in both cases, as they have already been performing well regarding their environmental impact.

Other building elements included in the calculations are the structural wood, windows, exterior coatings, elevators, screws, and foundation. The source of the used EPDs is Oekobaudat.de. The calculations also include the operational energy demand for heating and electricity, as calculated by Be18, and multiplied with the weighting factors for the Building Class 2020, which can be found in BR18, 477, page 96.

Both scenarios get the highest possible score in DGNB ENV1.1 (Life Cycle Assessment Impact), however the replacement of straw bale to cellulose and wood to clay and linoleum reduces the environmental impact of the building further without causing significant impact on other factors.



	GWP	ODP	POCP	AP	EP	PEnr	PEtot
Second scenario	20,86	14,42	32,04	31,73	39,54	29,01	41,17
DGNB	100	100	100	100	100	100	100

Ill. 107. Comparison of environmental impact between second material scenario and DGNB reference

7

DESIGN PROCESS

Old building - findings and misconceptions
New building: initial steps
Volumetric studies
Plan development
Roof development
Play plaza design
Apartment development
Openings study
Nordic aesthetics in cladding
Facade material study
Interior finish material palette
Solar shading
Selection of main active startegy
Life Cycle Assessment of the PV panels in multiple life cycles
Outdoor area formation

OLD BUILDING: FINDINGS AND MISCONCEPTIONS

Phase 1: Old version of Ouroboros, achievements and misconceptions

During the process of creating Ouroboros, there was an attempt at solving the problems. However, because of various circumstances, in both methods and results, that attempt was considered to be lacking. However, that project laid foundational elements and ideas which have been used throughout the entire project. Additionally, the lessons learned from the creation and re-evaluation of that project informed design decisions in the latter part of the project. So, to fully grasp the entirety of the project's process, we intend to discuss the process of the first version of the project to illuminate the influence of that project on the whole.

The Inception of the Idea

The nucleus of the project was built on an intent to utilize clever use of architecture to facilitate deepening bonds between people. We discovered, almost, unutilized resources to create a beneficial relationship in the current social environment. The resource was the lack of quality time between kids and adults currently in Denmark and the increasing number of the elders, as well as the feeling of loneliness and isolation they deal with. Intergenerational facilities are not a new concept; however, they haven't been thoroughly explored in the architectural sphere. On the contrary, such facilities, as an architectural typology, are rather undefined at the moment. What constitutes an intergenerational facility? Some institutions are more akin to the usual typologies with just an external visiting system in place. Are these facilities also intergenerational? Secondly, when discussing putting two user groups together, who normally are taken care of separately, what amount of unity is the right amount? We, from the inception of the project, believed that the two groups could, not only exist in the same facility but alleviate some of the inherent problems found in their respective typologies. Dealing with a complex issue, such as the benefits of social interactions, it is impossible to determine the actual benefit, without building the proposal and having it operating for a minimum of a year, while interviewing the users periodically. Therefore, to determine how we could generate these wished benefits, we have to look towards research papers on the subject. We then have to design the architecture around some of the commonalities found in the papers, and then believe these initiatives will result in social enhancements. From the starting point, the viability of the fusion of institutions and the ability for us to verify the success was uncertain.

When starting, the research of the psychological and social effect of children and elderly people interacting was paramount. We found a large amount of research on the interaction of these kinds of relationships. The research of Min-Young Seo (Seo, 2006) proved fundamental in establishing the groundwork for our evaluation of the social level. The work gave examples of what spatial enclosures stimulate elder and child interaction. Alongside knowledge from other such papers, the social phenomena were understood, and we could now start designing spaces with any sort of basis for evaluation.

The major technical aspects of the project were decided early on to be DfD because of specific reasons. Firstly, the building typology and social paradigm is a form of a social experiment, the actual outcome of the social paradigm is impossible to verify without establishing the facility. So, to minimize the potential risk of a hypothetical contractor, the building should be easily rebuilt or remodeled, which DfD allows us to do. Secondly, the research on circular buildings, such as the one we wished to create, suggests that DfD is used to ensure that materials can safely get detached and return into the market loop.

Exploration of the Concept

The original project was an evolutionary process where the concept evolved on a linear progression over time until a complete concept re-evaluation in the final weeks of the project. However, the way the process was handled addled mistakes that resulted in a bland and uninspired project. The basic concept of the building revolved around creating circular loops to decrease the maximum distance within the building. These loops were to service each of the three different types of users; staff, elders, and children. Initially, the project swayed towards weaving these loops together creating scenarios where the kids and elders were very close together. However, the problem with these concepts was that the intergenerational activity spaces had a lower placement in the hierarchy. The concepts, although having proximity between elder and kids, was very disjointed and segregated, and the intergenerational spaces, which in retrospect are the core of the building concept, were in-between spaces. A paradigm shift happened in the latter part of the project. The concept changed where the three loops were preserved, however, the intergenerational activity space had a central position in between the loops. Through the evolution of the original project, the focus changed from the apartments of the elders and the group rooms of the children to the common areas where intergenerational activities will take place. The big revelation from working with the concept in its first version of the project is the added focus on the places where the users meet.

The Initial Unity Problem

So, when working with an intergenerational facility the main question concerns the ideal level of integration between these two user groups. We chose to dub this the unity between them. In the first version of the project, the unity changed during the paradigm shift,

Ill. 112. Old Ouroboros

when the activity area became the central piece. Initially, the project included a unity where the kids and elders were placed closely together. However, during the process, the kids and the elders got more and more segregated. One of the main reasons for this shift to occur was because of a hierarchy shift in the building, and our fears regarding the building's ability to deal with pandemics. We began to fear the idea of putting the biggest disease spreaders with the most vulnerable people. This was mainly because of the time when we were developing the project, in the 2020 COVID-19 pandemic. We faulty started to design the building for use in an emergency, instead of nurturing the relationship of the everyday. We valued the high functionality during pandemics, over better interaction during all other times.

The Faults of the first version of Ouroboros

The first version of the building had several mistakes. Mistakes whose lessons we took into the next phase of the project. Firstly, the process structure was completely mishandled. We completely disregarded the first tenet of integrated design. We split responsibilities into our different expertise. This made it so that the different parts of the project developed separately without much push and pull in between the different parts. Secondly, the realization of the actual important area of the building was left woefully underdeveloped. Additionally, we were under the fallacy that the activity areas should be designed as general, without any form of characteristics to define them, except for furnishings. We believed that the activities within the building should evolve through experiences and time and therefore it wouldn't make sense to design something if it would change. However, we now know that the building should invite into these activities through careful design and planning. The whole argument with the adaptive needs of the future doesn't make sense when designing the building to be easily changed and adapted. Thirdly, the integration between architecture and technical solutions were severely lacking. The differences in the technical aspects made on the overall building's expression and concept were marginal. Fourthly, the unity of the users was, as discussed earlier, not utilizing the inherent benefits which could be utilized by this type of typology. Fifthly, the architectural expression and logistics were predictable. The building was compromised of a nursing home and a kindergarten that was coincidentally joined.

NEW BUILDING: INITIAL STEPS

Phase 2: The new Ouroboros

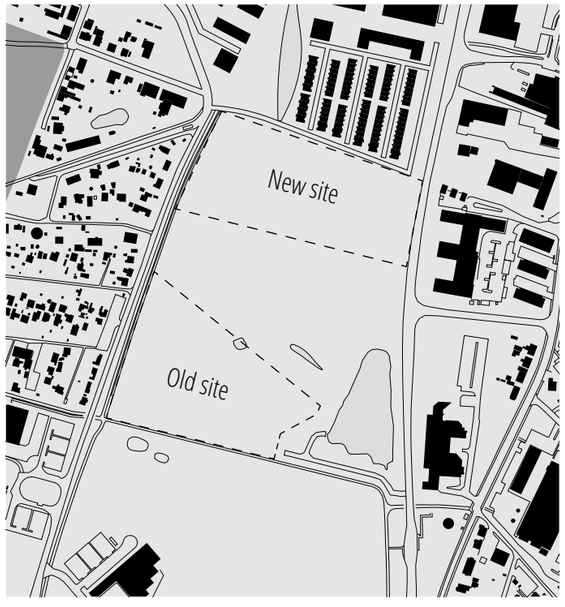
The second phase of the project is made after the original attempt failed. The project is an evolution of the ideas and ideals of the previous project. This phase, however, seeks to use the lessons learned from the previous project, but completely redoing the architecture and technical aspects, while enriching the theoretical part and ensuring its implementation into the design.

The Unity Problem

When designing an intergenerational facility, the alpha, and omega of the project is the unity. So, throughout the entirety of the project, this question has been on the table. We identify three general levels of user integration, or, in other words, three levels of unity. First is the total segregation. This form is what the previous project used. This level of unity allows each of the separate care-taking facilities to function as per normal but allows the users to freely interact. The pros of this kind of setup are that it allows the staff to properly control the individual groups and the users have autonomy over their involvement in the intergenerational activities. The consequences of this unity between users are that the people aren't exposed to one another in any natural way, therefore eliminating the passive interaction one needs to start generating closer bonds (Gehl, 1987). The second level of user integration is total unity. This one is a total mix of kindergarten and nursing home facilities. In this setup, the two parts are virtually indistinguishable from one another. This kind of facility should make all the users interact to a larger degree. Although it may seem to fully integrate the two users in their best interest, it creates problems regarding maintaining the well-being of the users. Firstly, from an organizational standpoint, the benefit of dividing the kids into different group rooms becomes muddled and the staff may have trouble controlling the kids in setting the boundaries. Additionally, such a setup would demolish the sense of backstage for the elders (Goffman E., 1956). The private spheres of the elders would instead be invaded by the curious kids. The third level of user integration is semi-unity. This form does not have one set up but is a gradient. The two user groups are close together, but it still allows them to exist as individuals. This setup should allow passive and active interaction while still allowing the elders to maintain their backstage. The semi-unity proved to us that was the model to go with, however, because of the non-extrema nature, it proved to become a gradient of possibilities. Questions like how much integration is too much quickly became a topic of discussion during the process. If we avoid striving for much integration out of fear for future pandemics or out of fear of having the elders disturbed from the kids, then the user integration would be from low to non-existent and the project would become a coincidental fusion of the original typologies. If the user integration was too much, the integrity of the well-being of the users would be of detriment. So, during the entire process, this question was always present. Whenever big changes would be made to the building, we always re-evaluated that the chosen amount of unity was appropriate. Although these discussions seldom led to us changing, mostly due to the argumentation from the research sources, it still became a major part of any design process. So, when reading along the design process, do keep in mind that the question of the unity of the building was always up for debate.

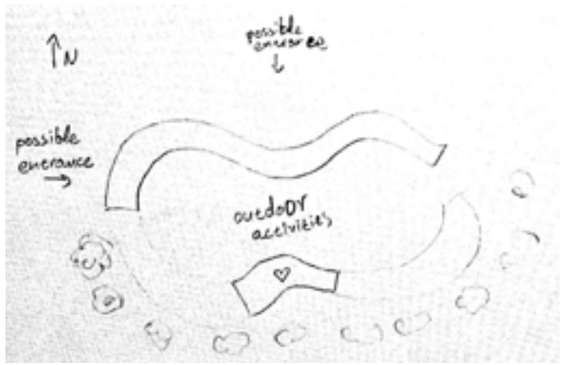
Moving Sites

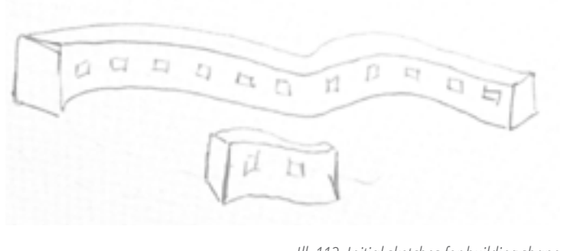
During the first project, we had a different site. It was just south of where the final proposal is situated. During the second phase of the project, we decided to shift the site to the new placement. This decision was made because of a couple of factors. Firstly, during the first project, the context had very little influence on the overall design. Secondly, after physically visiting the site, something we choose to not do during the first project due to COVID-19, we discovered the under-construction mixed-use district of the Frederiksbro project (Frederolsbro.dk, no date). Moving sites allows us to build into a developing syntax, and further develop the new area. The new area helped further the plan development and break the grid-system to bring variation into the building's plan.



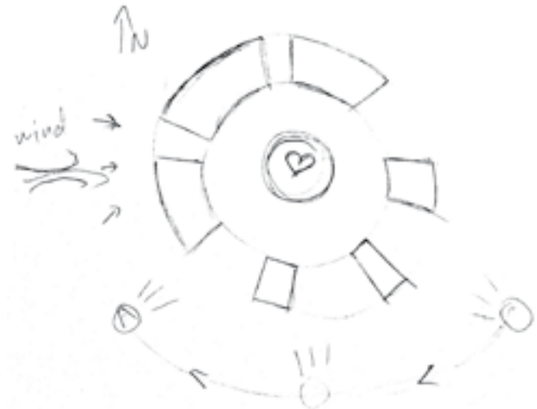
Initial ideas

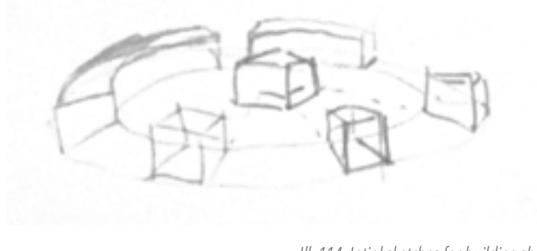
Understanding the context was our first step. By now we knew that there are main roads on the East and West of our site, a smaller road on our North, where the new district is currently being constructed, and nature -grass- on our South. Additionally, we knew that the heaviest winds come from the West and our users would mostly be active from the morning until the afternoon, therefore we need to make sure that both the interior spaces and the main outdoor areas have plentiful sun provision during this time.





Ill. 113. Initial sketches for building shape

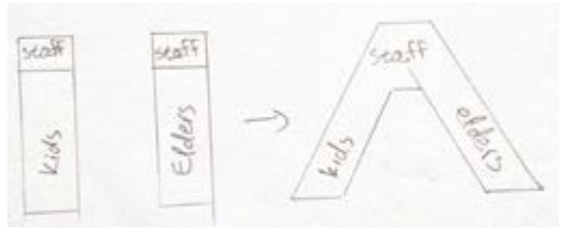




Ill. 114. Intial sketches for building shape

The initial ideas have revolved around shapes that would allow the users to interact and isolate according to their wish. The climate conditions of the site have been part of the shaping. Ill. 68 expands from the West to the East of the site, making use of the space and inviting the light in. However, it creates a barrier between our outdoor spaces and the new district and leaves the outdoor area exposed to the western wind. Ill. 69 tackles this issue by being oriented facing the to the Southeast.

Although initially it was estimated that a non-monolithic building would add to the home-like experience, it was realized that merging the areas for the kids to the areas for the elders would provide more opportunities for intergenerational interaction. Additionally, the merge should improve the everyday life of the personnel, as providing them direct access to all areas should allow them to cooperate closer and supervise the rest of the users easier. Understanding this, led the concept to take the shape of an angle.



Ill. 115. Merging the spaces

Starting to integrate

When starting the process of designing the new building, we examined the last project to identify the problems that had plagued it. One of the main reasons for that project's unsatisfactory state was its lack of integration between the processes. So, the first step was to start integrating technical aspects earlier into the design process. Another major factor in the last project's faults was its reliance on active strategies to maintain a satisfactory energy and comfort level. So, we identified a large contributor to the building's inefficiency was sprawl. The building needed to become more compact. This would reduce the envelope to floor area ratio. To start, we made some basic volumetric studies to start generating ideas about new buildings. However, this study shouldn't be like the old process, so we set down some new forms of restrictions and exploration subjects. Firstly, the building should strive to achieve higher compactness. Next, we should look at the energy frame of the potential design. Finally, functionality and unity should be discussed. Through this study, we gained a minor breakthrough concerning the placements of the different functionalities. Initially, we believed that the staff's functionality was the only part of the building to be relegated upstairs, to lessen the physical barriers between the users. However, we discovered that the space required for the staff would only constitute a small amount of the overall building area. This would only somewhat lessen the sprawl of the previous project. We needed to move other parts of the building upstairs. Initial thoughts led us to believe that the children would be the best choice, however, after some consideration, the elders would be a better choice. We needed the intergenerational spaces to be accessible to all and we needed the possibility to be able to move outside, Additionally, we needed to integrate the elders into these activity spaces, while still making sure that they have the opportunity to move in and out of their private sphere. By moving them upstairs with a possibility to move directly down into the activity area, we would create a psychical boundary to allow the elders to maintain their privacy if wanted.

The next problem is then how much could we move them? We tried to make a version where the elders were dispersed into 2 floors. However, these were deemed both to large a divider and a detriment to the community of the elders. So, from these quick studies, we get the final building's division of kids and elders.
The next problem that needs to be tackled is how do we create a social connection between floor levels. We then started developing the concept, which through considerable work would become the final building. The inception of the idea of the concept of the building is built on the notion that if we place the elders' apartments on top of the children's group rooms, we could create a visual cohesion between the two levels through a central atrium. Additionally, by doing this setup we could make the elders, when not in their private units, be passive observers. We then create an area designed for even the lowest level of intimacy (Gehl, 1987). If we then orientate the apartments to be looking east and north, we then make the elders look towards activity, as they would be looking at the playground area of the site and the open area in Fredriksbro, leaving the Southern view of the top floor available for public gatherings among the elders. We then tied the line into a loop which would, like in the old project, decrease the maximum distance in the building and make navigation within the building easier for the users.

Plan development

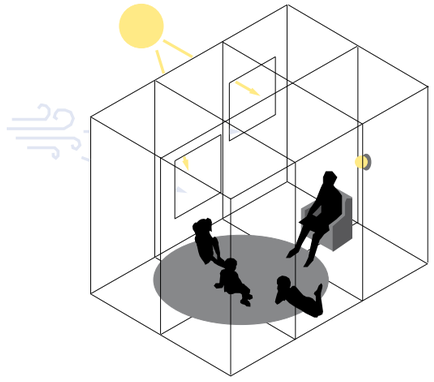
When starting the plan development, we started by discussing the initiatives we needed and wanted to be able to complete the building. Firstly, the placement on the site. We of course needed a building that created an outdoor space that wouldn't be shaded by the building itself. So, we elected to place the building on the westernmost part of the site. With this placement, we could connect to the planned infrastructure to the west and north of the site. Additionally, the kids would be in the facility from around 8 – 17, so by placing it at the east we would allow the sun to shine at the outdoor areas while intergenerational activities take place. Finally, as the wind rose of Roskilde indicates, the heaviest wind comes to the site from the West, therefore, by blocking it through the placement of the building, we provide a much more pleasant outdoor environment to the users.

The next thing we discussed was the implementation of the different intergenerational activities, and the specific conditions we needed in the intergenerational activity rooms. So, we first took all of the individual activities and paired them into different rooms. We needed to make sure that we achieved as many double-functionalities as possible. This is because of our new philosophy on designing the activity spaces. We needed to make sure that these function-specific spaces were not in mostly disuse, becoming superfluous space. Lastly, we divided the functions into the different cardinal directions, making so the staff functions were mostly on the north and west, while activity spaces were to the south and east.

REEADING ALONE

- minimum distraction
- semi-privacy
- adjustable lighting
- warm in sedentary position

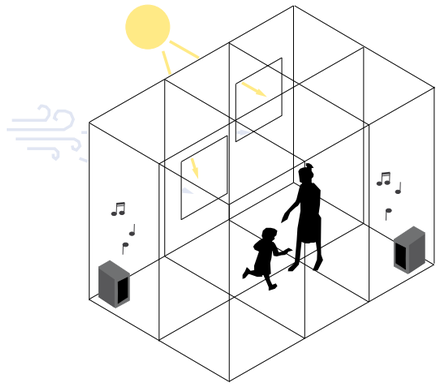
Texture: warm, e.g. wood, carpet



REEADING IN GROUPS

- need to be heard: dead acoustic quality
- visual contact between reader and listener
- reduced external distraction
- warm in sedentary position
- comforable sitting
- adaptable light levels
- intimate setting

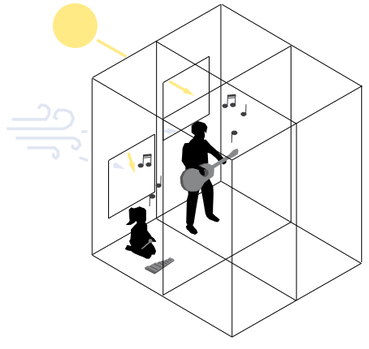
Texture: warm, e.g. wood, carpet



DANCING

- spacious
- manual control of light
- thermal comfort for movement
- comfortable air quality for excersice
- absense of physical boundaries

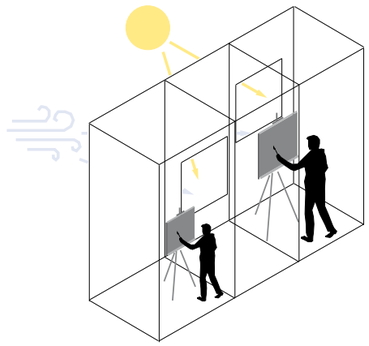
Texture: hard floor, smooth walls



MUSIC

- deader acoustics
- indoor comfort for semi-active users

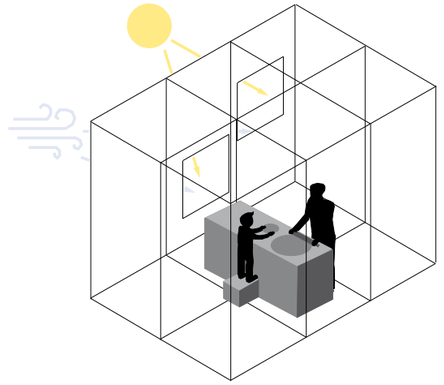
Texture: sound absorbant surfaces



ARTS & CRAFTS

- plentiful light
- movable objects
- high air quality
- openness
- displaying surfaces

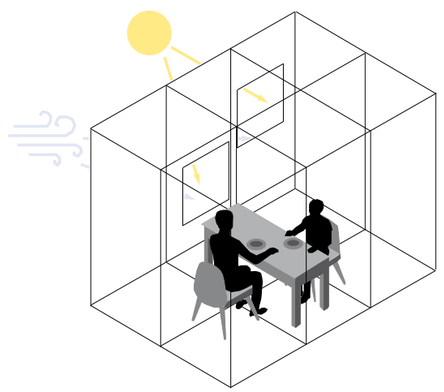
Texture: easy to clean



COMMON KITCHEN

- sterile
- easy to clean
- spacious
- reflective surfaces
- high air quality
- inviting
- open

Texture: smooth

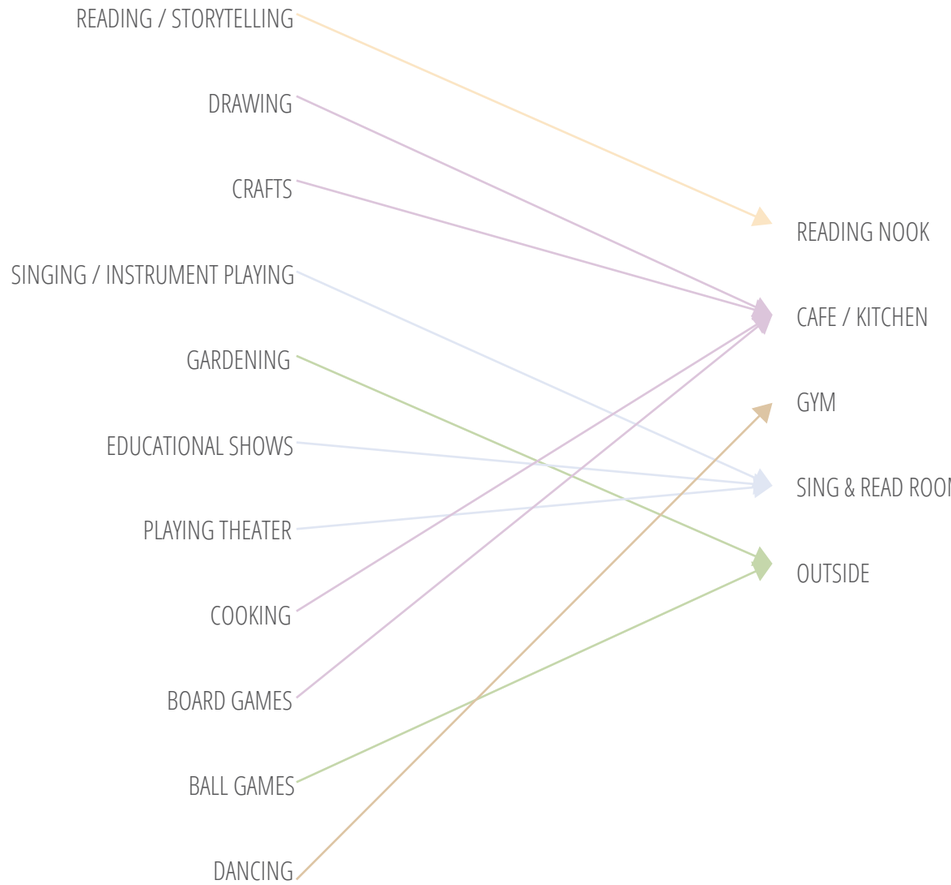


EATING

- comfortable
- spacious
- aboundant daylight
- easy to clean

Texture: warm

Ill. 116. Spatial requirements of designed activities

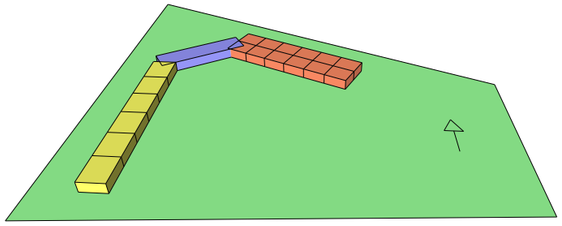


Ill. 117. Pairing the activities to spaces according to their spatial requirements

VOLUMETRIC STUDIES

Here, the volumes of the first concept have been tested under different placements to observe ways for them to connect and interact. The size of each indoot area has been roughly determined based on the room program.

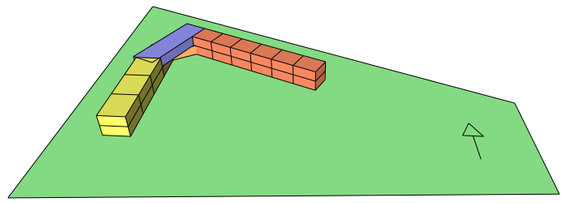
Kids
Staff
Elders
Common areas



Building envelope: 2937 m²
Heated floor area: 1071 m²
Framework for operational energy demand: 41,94 kWh/year
Envelope to heated floor area: 2,74

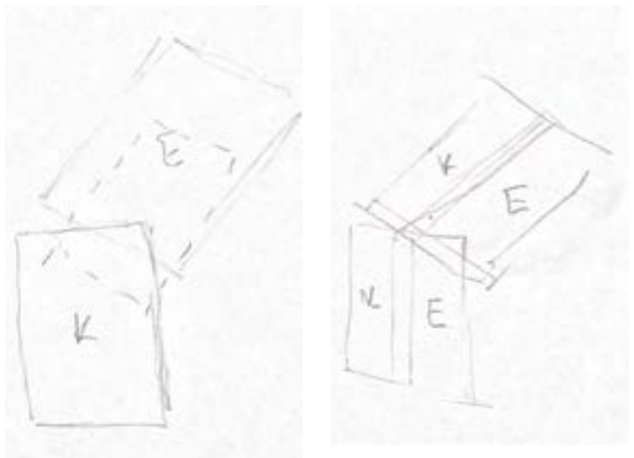
Firstly, there has been an attempt to place all on the ground level for ease of access and movement from all users. The positioning happened by following the limit lines of the site and the idea is to shelter a big part of the outdoor area from the regular, harsh wind from the West. This scenario appeared to be excessively spread and therefore might not be as user friendly as wished, particularly for the staff.

The volumes have been distributed in two levels to observe how this can create a more intimate environment. Additionally, the common area starts to form in the meeting point between kids and elders on the ground level, where entrance can also be placed. However, it can be observed that there is high user segregation, while also the orientation of the elder units is not ideal, as they either have to have a southwestern view, in order to have visual contact to the main outdoor active areas, or have a northeastern view, but without plentiful visual stimulation.

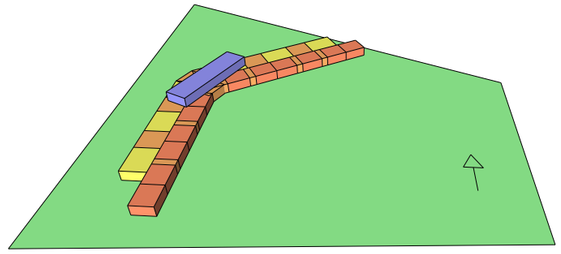


Building envelope: 2393 m²
Heated floor area: 1176 m²
Framework for operational energy demand: 41,85 kWh/year
Envelope to heated floor area: 1,99

THE ANGLE

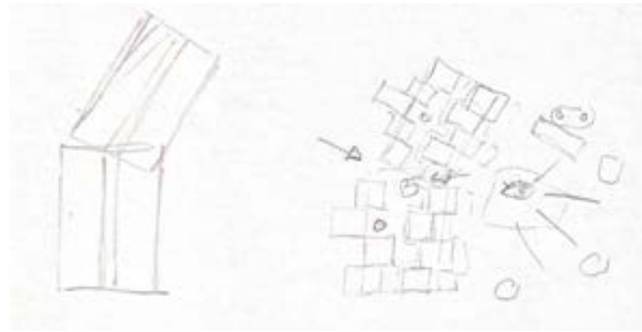


Ill. 118. Kids and elders allocation in space

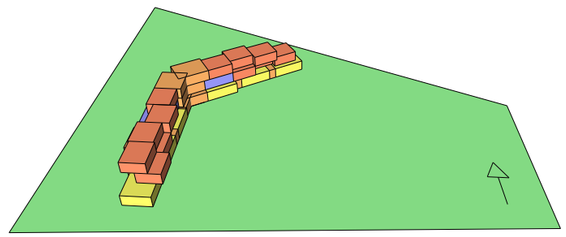


Building envelope: 3452,5 m²
Heated floor area: 1393 m²
Framework for operational energy demand: 41,72 kWh/year
Envelope to heated floor area: 2,38

The kids' group rooms come to the eastern and southeastern side of the building to get the most out of the morning sun. The majority of the common areas are moved to the west, but also have mobile and viisual access to the east, where the main outdoor area is located. On to of the common areas, the elder units are placed, as well as the staff offices. This placement allows for the creation of terraces for the elders, where they can enjoy the view to the main outdoor area, while being protected from the western wind. However, while striving for uniformity in the visual environment in the elder units, it was resulted that the upper floor exceeds the limits of the ground floor, which, although can be technically solved, creates an aesthetic issue.



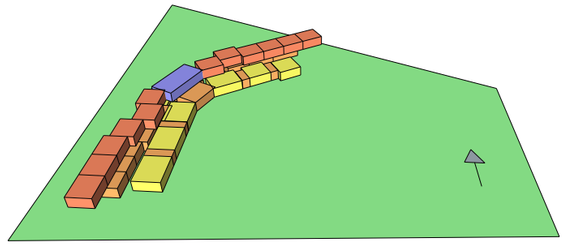
Ill. 119. Shape fragmentation



Building envelope: 2240,9 m²
Heated floor area: 1272 m²
Framework for operational energy demand: 41,77 kWh/year
Envelope to heat floor area: 1,74

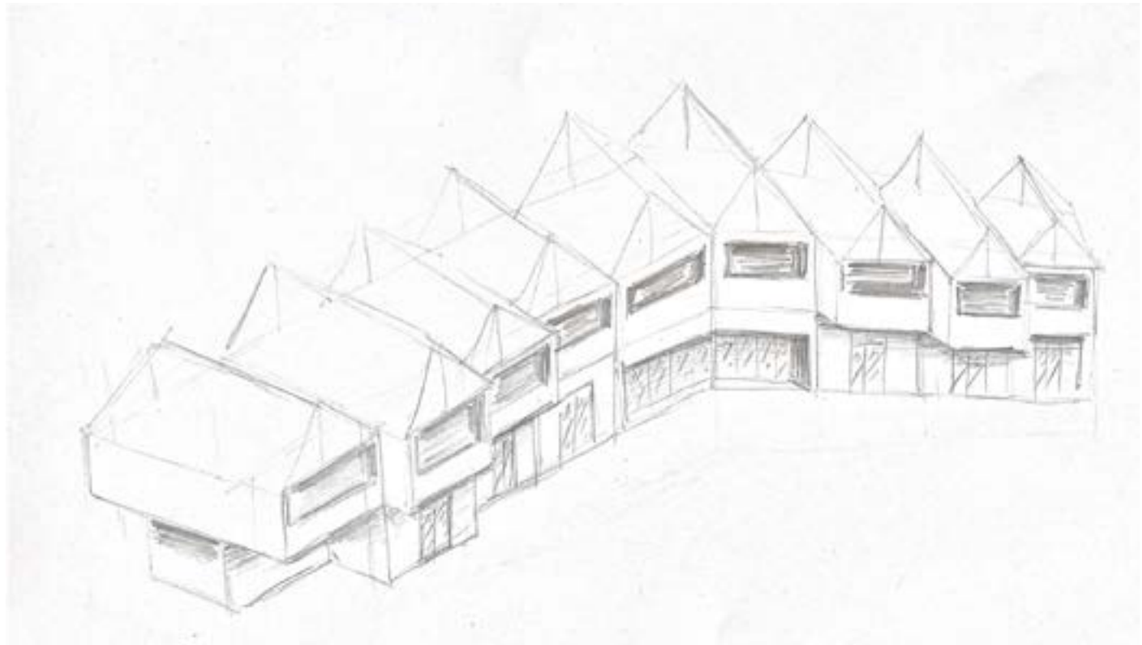
Operational energy framework is calculated according to BR18 259 for non-residential buildings, p. 55

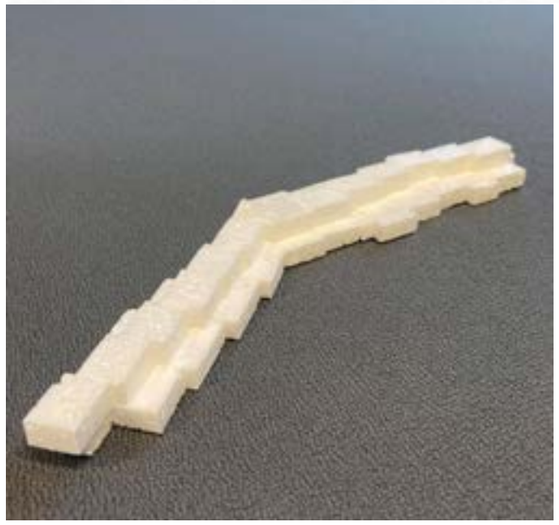
To achieve user integration, here it is attempted to bring kids and elders on the same level, allowing only staff offices on the upper floor. Additionally, the orientation of the part of the building changes, to allow for all elder units to get plentiful morning sun. Here, the issue with the layout being excessivelly spread returns, while at the same time, the kids' group rooms, which are primarily used during the day, only get western and northwesten views, which can be problematic regarding provision to natural light, as these group rooms are expected to be mainly used during the morning.

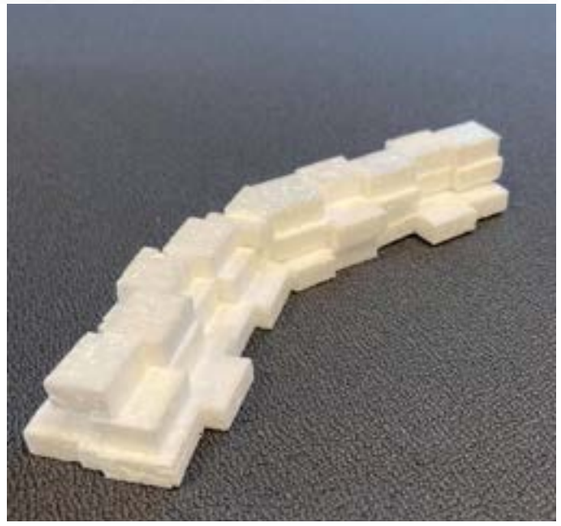


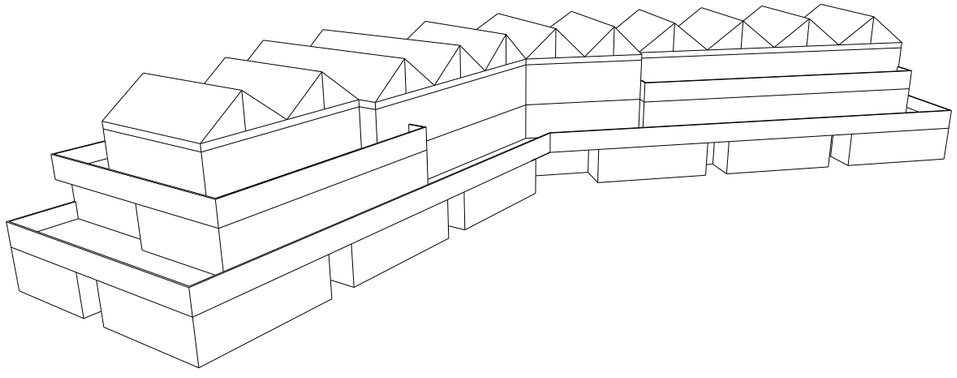
Building envelope: 3331,5 m²
Heated floor area: 1124 m²
Framework for operational energy demand: 41,89 kWh/year
Envelope to heated floor area: 1,99

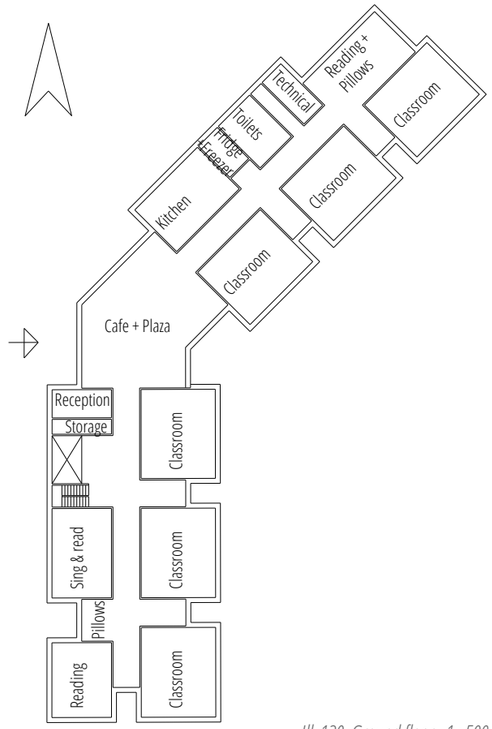
The solution is to distribute the elder units in two floors, resulting a three-storey building. This way, all similar units have similar visual environment conditions, while the main outdoor area is sheltered from the western wind. Semi-integration of user groups is achieved while the need for privacy of the elders at times like visiting the nurse's office is respected. The main common areas remain on the ground floor while in the angle of the building on the uper floors there is created the possibility to form an atrium and and space for semi-private activities on the perimeter of it. Finally, the idea of breaking the total volume into smaller fragments should create the feeling of a neighborhood of small houses next to each other while allowing for shadowing to the openings exposed to the South to avoid overheating.



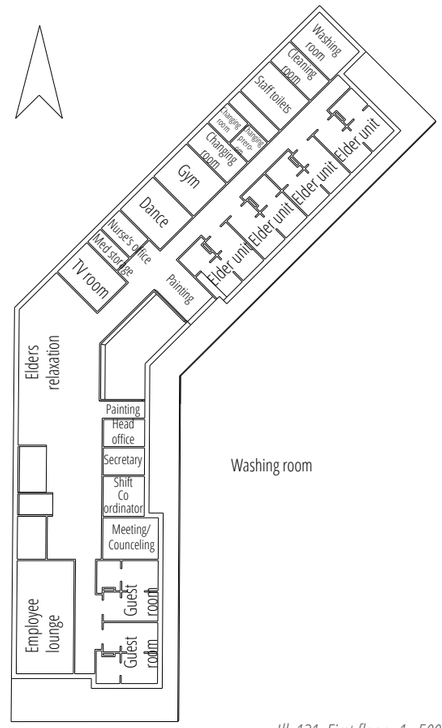




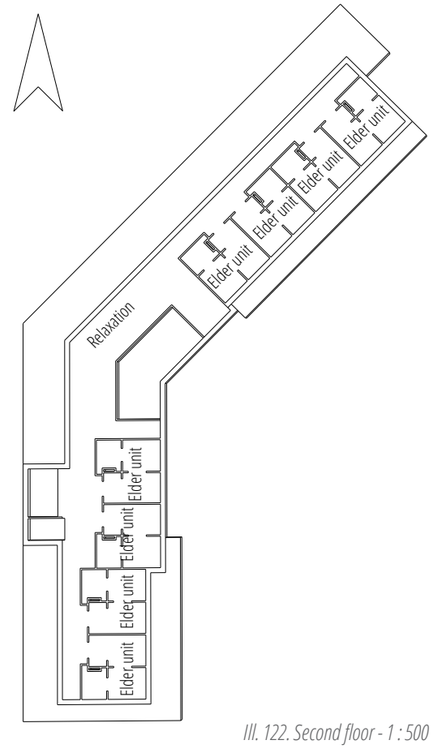




Ill. 120. Ground floor - 1 : 500

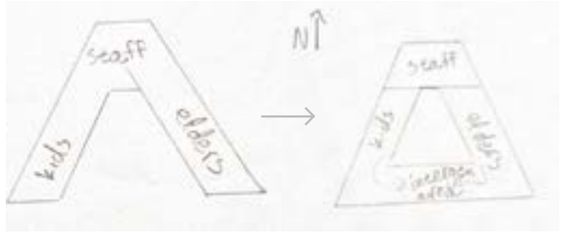


Ill. 121. First floor - 1 : 500



Ill. 122. Second floor - 1 : 500

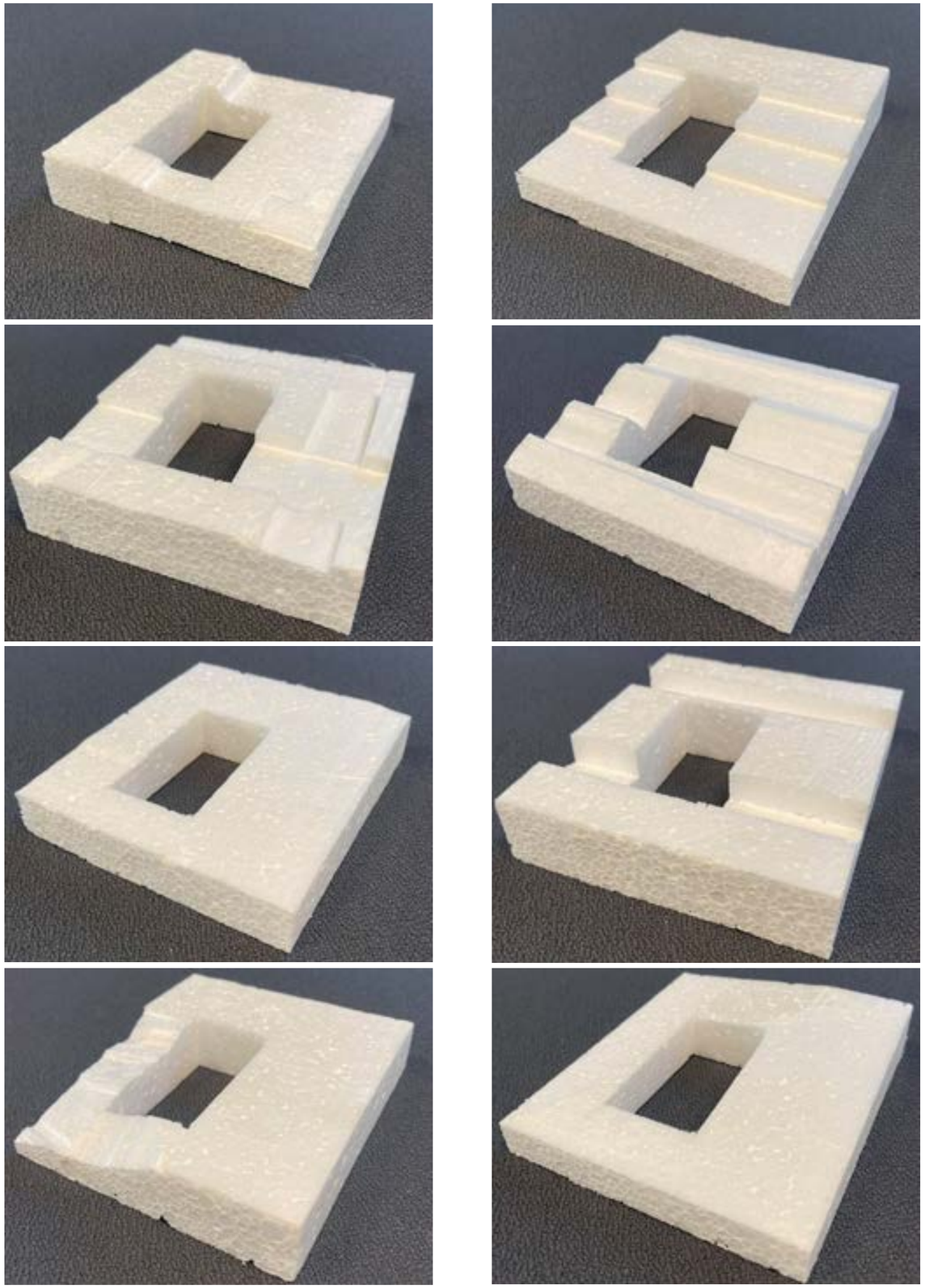
The angle had some of the qualities the team was going for. It explored several levels of user integration, as well as the levels of compactness of the building to avoid the mistakes regarding the operational energy demand of the version of Ouroboros. However, it still felt that some areas are too far from each other, reducing the opportunities for the users to meet and interact, while the staff would still have a hard time keeping an eye at all areas during all times. For these reasons, it was decided to join the two ends of the building, which should solve these issues, and ease the process of navigation for the users, as there would not be a wrong direction anymore.



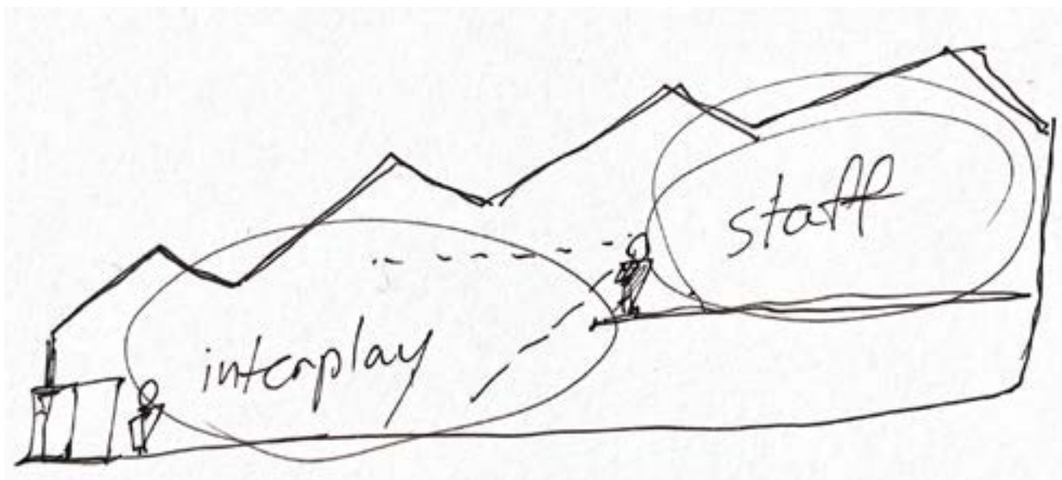
Ill. 123. Closing the loop

THE BLOCK

The process of adjusting the shape and rethinking of the connections between the newly joined areas resulted the Block. The shape was further explored through foam models, with the scope being to investigate the possibilities of the form while remaining open towards the sun (ill.123).

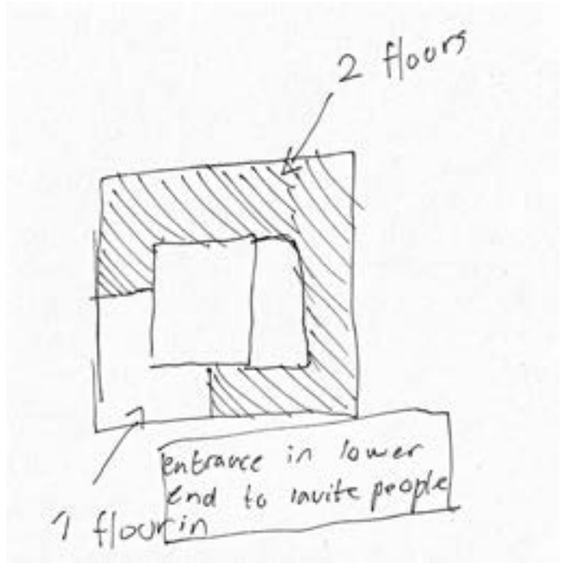


Ill. 124. Shape variations for the Block

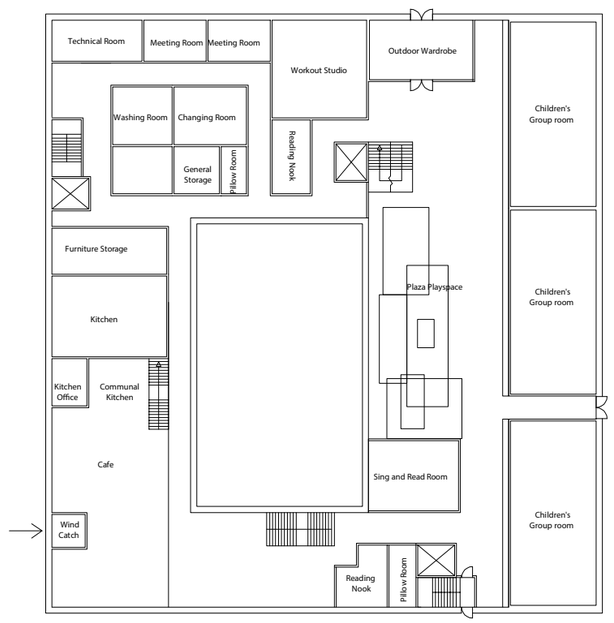


PLAN DEVELOPMENT

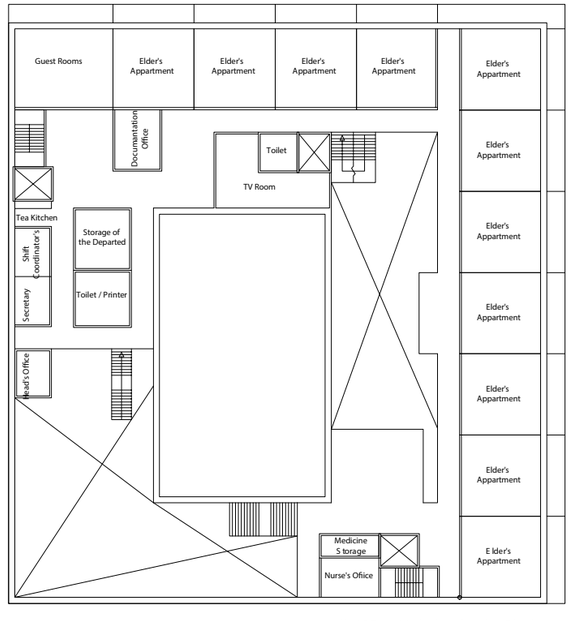
This led us to the first plan solution for the Block. This plan had some of the final plan's characteristics and placements. However, at this point, many of the ideas and spaces were underdeveloped (ill. 126,127).



Ill. 125. Concept sketches

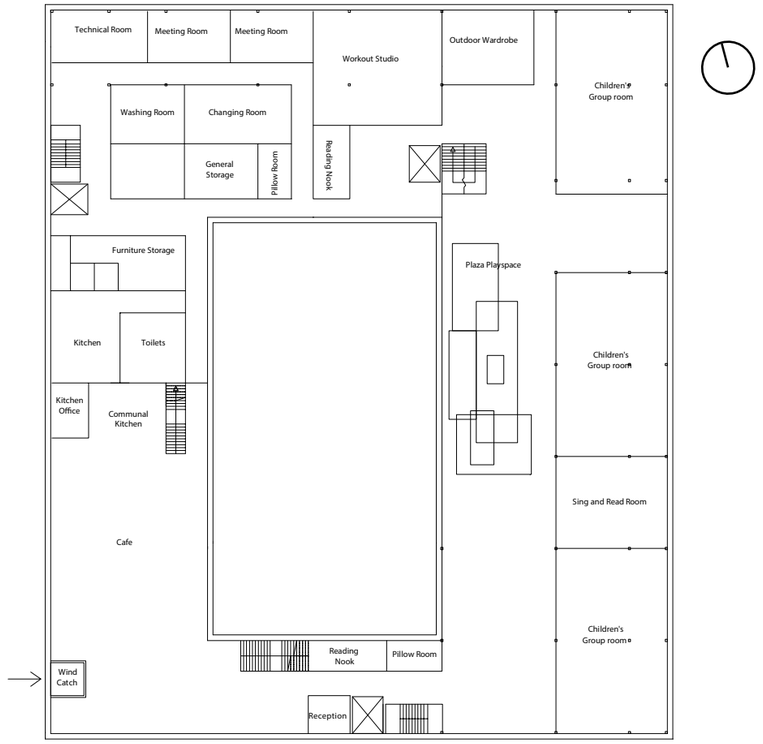


Ill. 126. Initial plan for the Block - Ground floor - 1:500

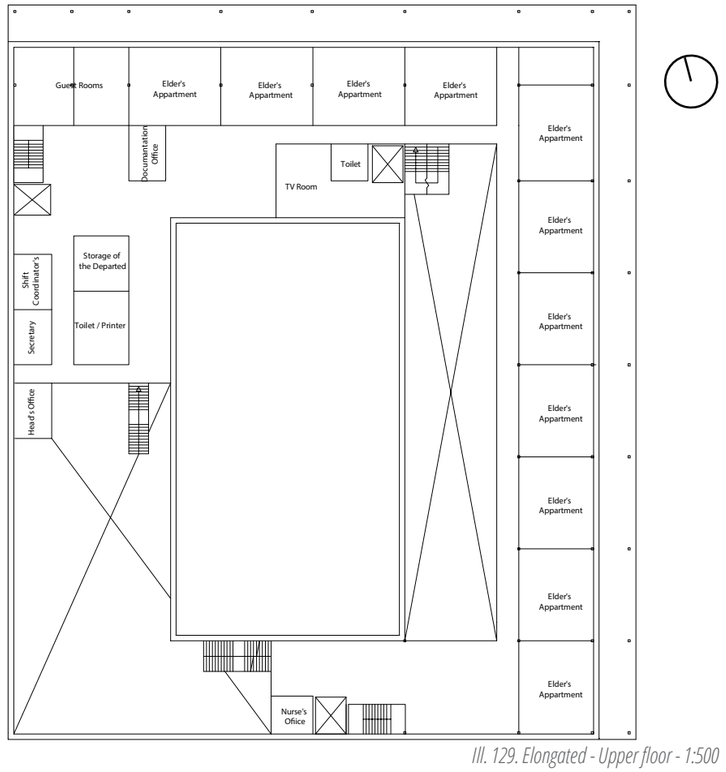


Ill. 127. Initial plan for the Block - Upper floor - 1:500

Through the process, we later elongated the plan to increase the eastern and western facades (ill. 128, 129). We did this to make sure there could fit in more functions in the eastern façade and make the gap space into a useable space. However, at this point, we identified a tendency in how the spaces we had, to this point, created. Firstly, we tend to create square spaces connected to other square spaces. The spaces had a completely functional flow to them. We didn't make spatial variations for any sort of effect. It was a purely functional drive. Additionally, this led the facades to be very one dimensional without any sort of three dimensionalities. Another idea of this stage that was disregarded was to break the uniformity of the orthogonal shape through creating niches, however, that was proven to not be working for us neither regarding the spatial qualities of the building nor regarding the energy efficiency and indoor climate quality, as it was increasing our building envelope and creating shadows in some of the spaces that had started to take shape.

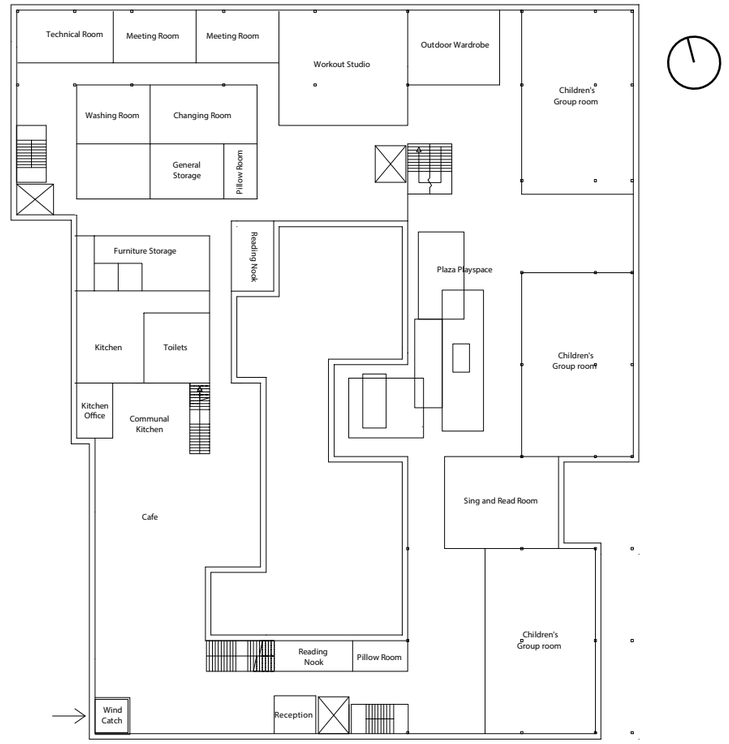


Ill. 128. Elongated plan - Ground floor - 1:500

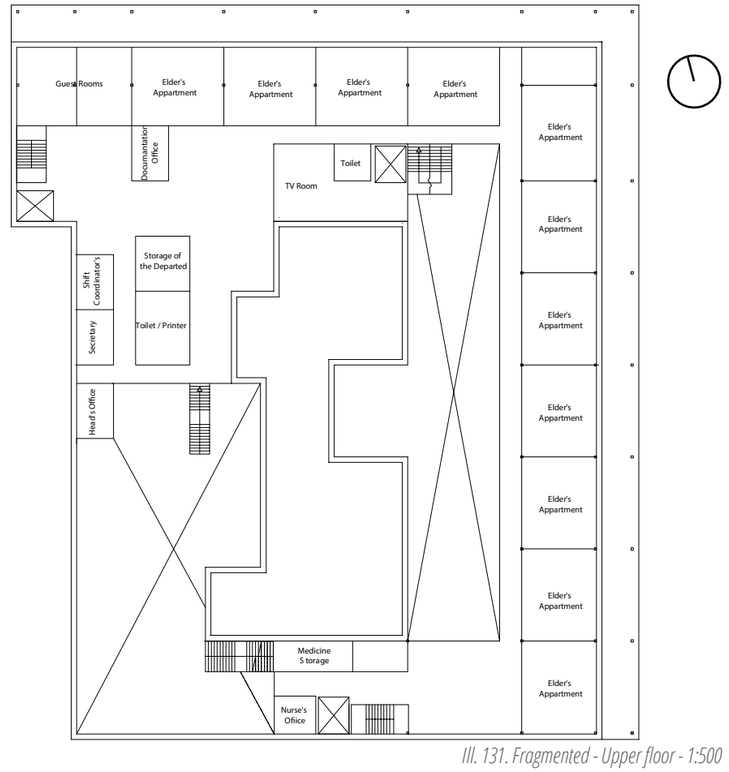


Ill. 129. Elongated - Upper floor - 1:500

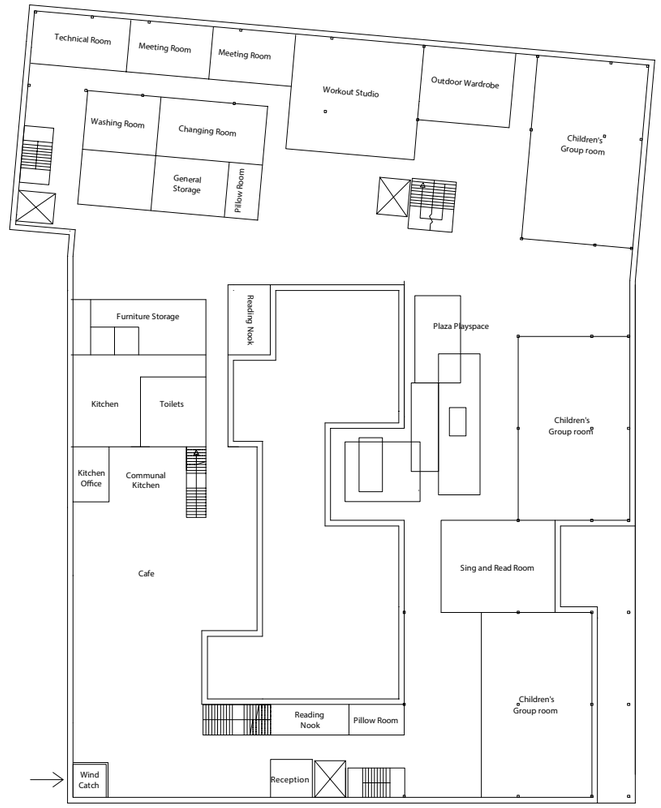
We started making a spatial variation of the plan (ill. 130, 131) to create some contractions and expansion in the play plaza area, as we knew it was the heart of the building. However, because of the way DfD is implemented into the design, necessitating an internal grid wooden skeleton, we could only make these spatial variations within an orthogonal system, to reduce customization of materials and components and allow partial disassembling without interfering with the load-bearing elements of the building.



Ill. 130. Fragmented plan - Ground floor - 1:500

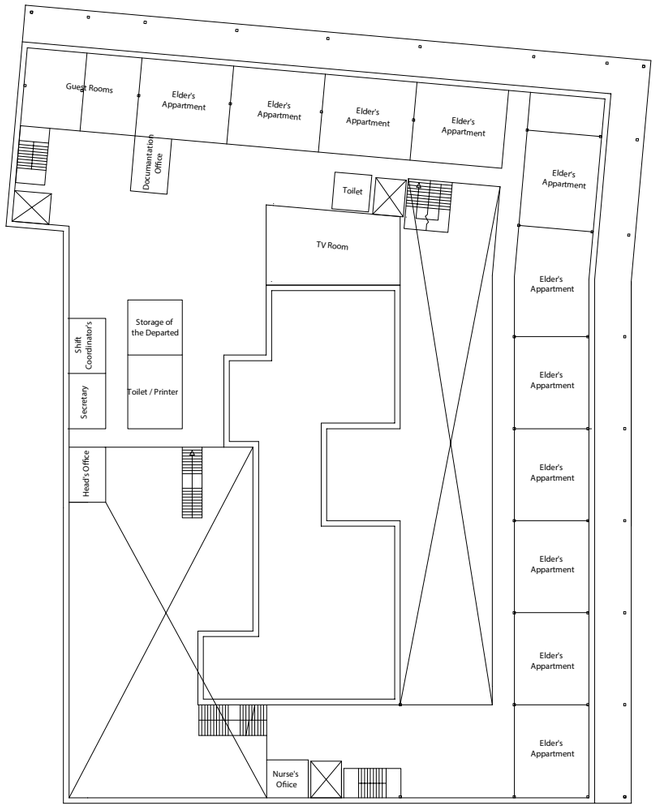


Ill. 131. Fragmented - Upper floor - 1:500



Ill. 132. Aligned to the site- Ground floor - 1:500

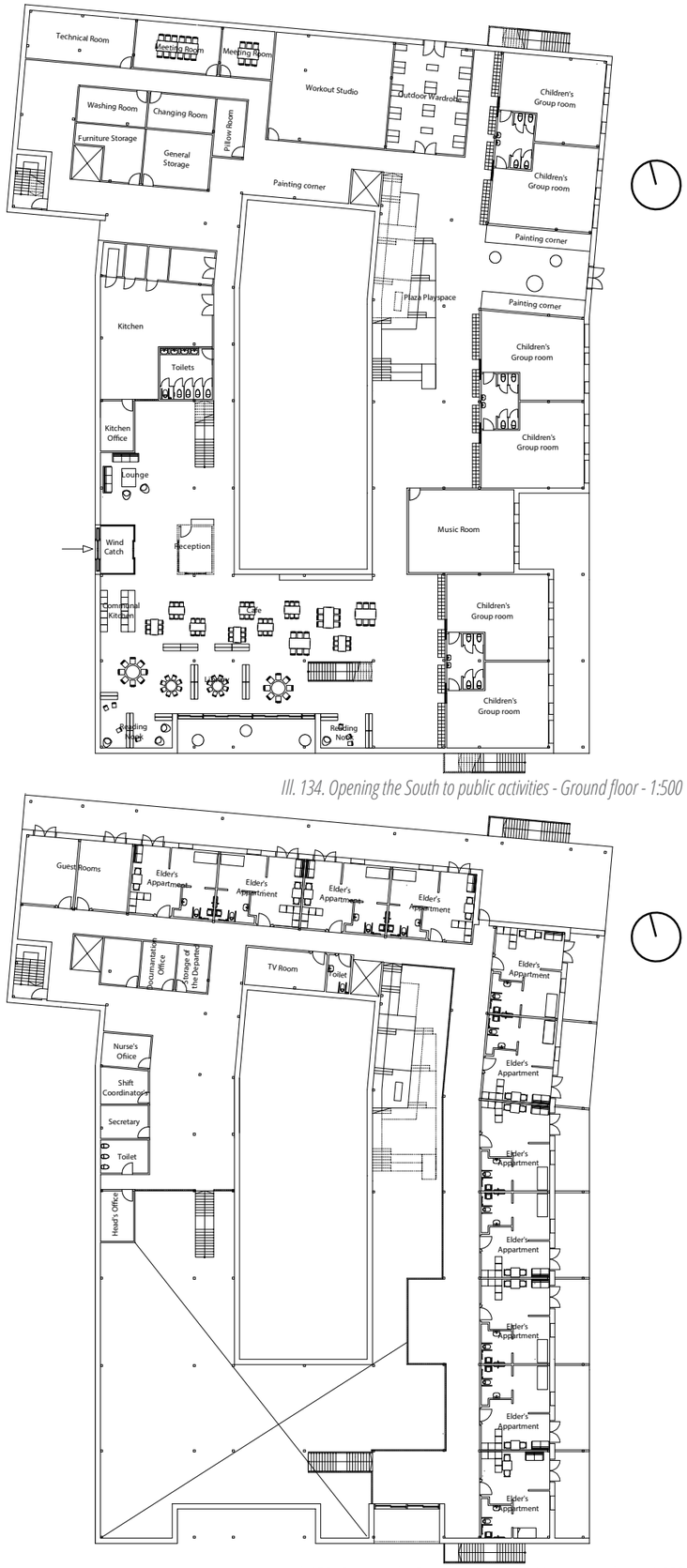
Being on the new site, we had a context to try to build up against. So, we decided to angle the northern part of the building to the syntax of the new area (ill.132, 133). This would allow the building design, as of current, to remain mostly unaltered, regarding the indoor comfort level. We deemed it a necessity of the overall context cohesion and acceptable compromise within the DFD and reusability aspects of the building. Having only two places where the different grid would connect, it was not too big of a problem.



Ill. 133. Aligned to the site- Upper floor - 1:500

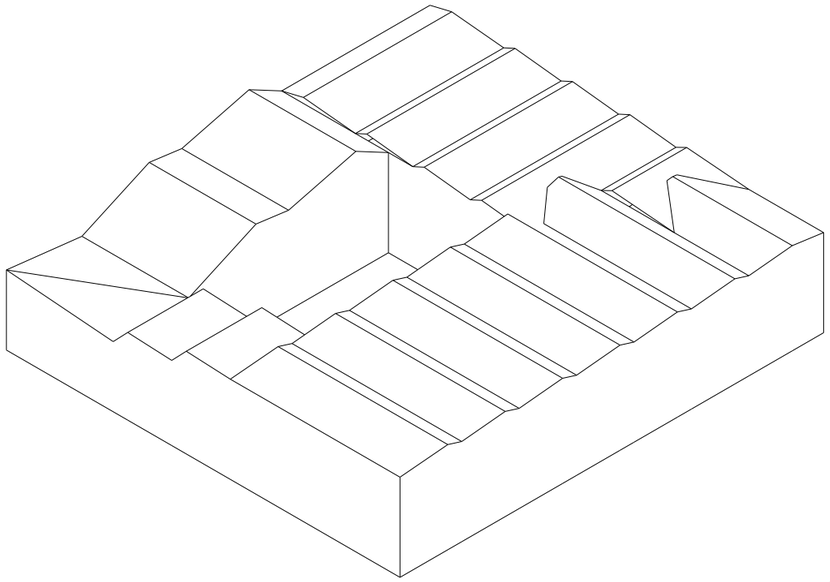
The last major plan development was the moving of the café area to the south. This change was caused by several factors. Firstly, the café was a disjointed part of the overall intergenerational core of the building. Secondly, we needed to create more zone where elders could passively interact with the children. So, we turned the South into a café and library with the reading nooks embedded into it. This would allow the elders and kids to meet while the elders are doing things they normally do.

The DfD part of the project had an overall large influence on how we handled the plans of the project. We chose to follow the principles of DfD to the point that this strategy does not compromise the spatial quality of the building, yet that certainly had an impact on the overall shape and limited the deformations that we could implement into it. Additionally, having to design spaces with a common proportionality, in an attempt to "think modular", made it more difficult to design them.



Ill. 134. Opening the South to public activities - Ground floor - 1:500

Ill. 135. Opening the South to public activities - Upper floor - 1:500



Ill. 136. Initial roof shape

ROOF DEVELOPMENT

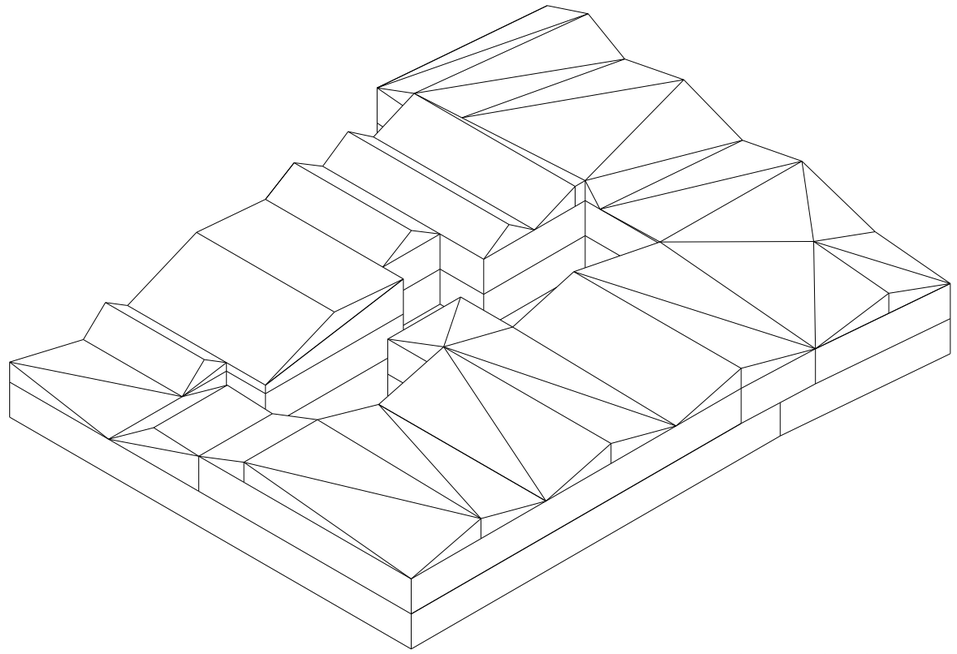
The roof concept builds on a reinterpretation of the traditional pitched roofs, you see throughout Hillerød and Denmark. The pitches would be deformed into a complete uniform shape, which gives the building uniformity of shape while keeping the traditional iconography.

Firstly, with the courtyard being established, we needed to make the building shade as little as possible. So, the south-side was to dip down to being one floor. The gradual process should additionally continue at the western side, to ensure cohesion.

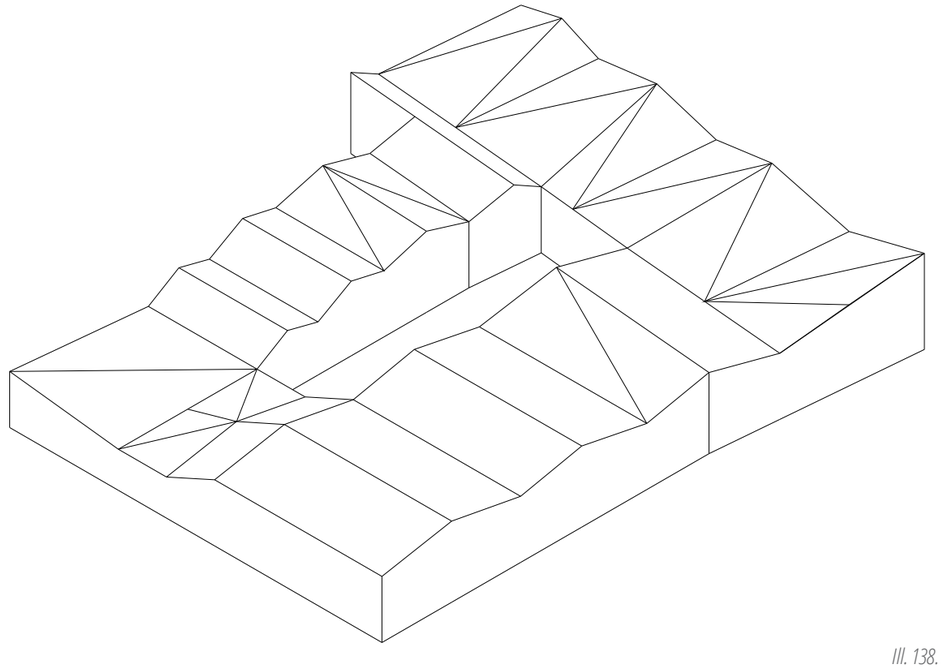
The first major roof concept was made in two parts. Firstly, we made, by hand, a roof with all the different pitches and their placements. Afterward, we made a Grasshopper script, which combined with an evolutionary algorithm was to deform the roof shapes. We chose to try to maximize the radiational energy produced on the roof divided by the total area created. With this setup, we would be able to create an efficient roof shape for collecting solar energy, while not overly increasing the building envelope. However, after further consideration and analysis, through BE18, we discovered that the electrical energy consumption of the building isn't its most pressing fault, energy-wise. We discovered that the heat-loss through envelope was the main benefactor to the building's energy-frame. So, the rationale of designing the roof for the gathering of a resource we easily could cover otherwise was debunked.
So, for the next iteration of the roof, we needed a new rationale for why we shape the roof. So, we decided to make the roof interact with the apartment-design. We made it so that a roof pitch would span over two apartments instead of one. This would allow us to have uneven heights in the dividing wall between apartments. So, we laid it out so that the bedrooms, which we consider the more intimate part of the apartment, have the lower ceiling, while the living room would benefit from the added open space. With this, we had spatially defined intimacy level, within the apartments. Additionally, at this stage, we needed the roof to align with the internal wooden skeleton. This was to ensure the structural properties of the roof, additionally, because the roof needed to follow the skeleton.

Lastly, when we moved towards the final plan solution, the whole southern wind rose in the hierarchy. So, we added a middle pitch in the gradient of heights. This was to further the spatial variation and create a sightline towards the floors.

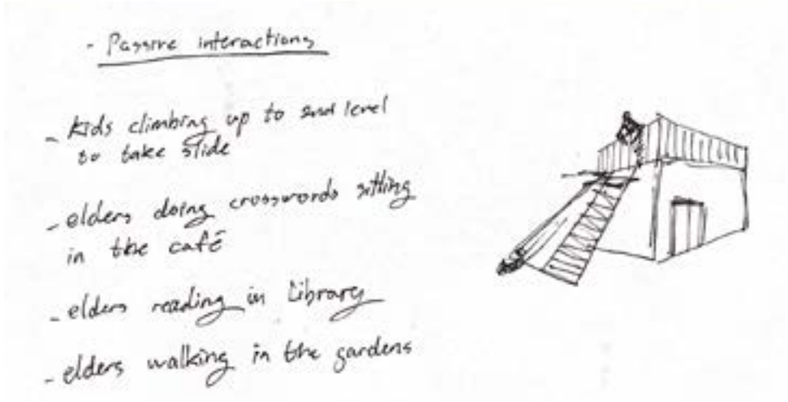
Additionally, through the entire process, we made solar studies for the roof shape to ensure that the steps we took were towards creating a better interior courtyard. This allowed us to compare our qualitative work with space with a quantitative measure.

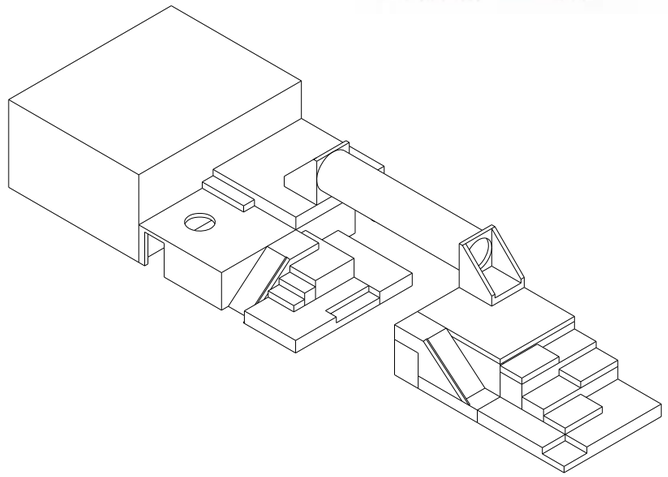


Ill. 137. Remodeling the roof after plan elongation



Ill. 138. Final roof shape





Ill. 139. Initial play plaza model

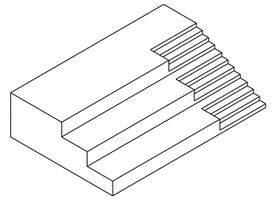
PLAY PLAZA DESIGN

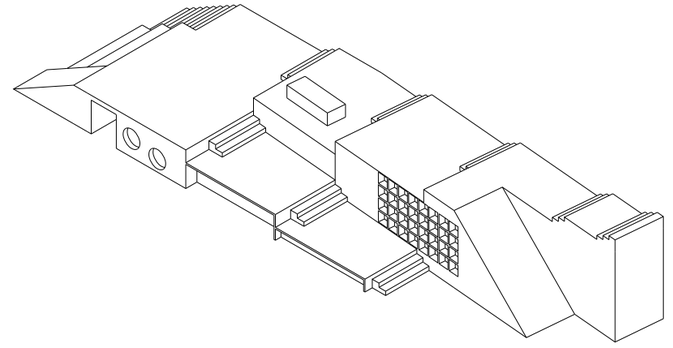
The need for the play-plaza came from a couple of sources. Firstly, the first project's total lack of actual activity space design, made it clear for us that we needed something in the building which wasn't room design. Secondly, we needed a way to draw the attention of the elders towards playing with kids. So, we hypothesized that if we create a play-space, which spoke to the motoric sense of the kids, we would draw the kids towards this area. With this initiative, we believe that through the knowledge that our eyes are drawn towards activity (Gehl, 1987) that the elders would be enticed to go down and play with the kids.

The first iteration was without the possibility to use it as a stair for moving between floors. We know, though, that the fundamental idea of it is to encourage gatherings and playing. We made it so that the kids could play on the upper levels while the elders could use the lowest level as seating. In its purest sense, an activity attraction, it could have worked as intended, however, we believed that the interaction between the kids and elders was paramount for the project. We discovered that the elder's needed to be included more in the whole structure and could serve the double function as a staircase.

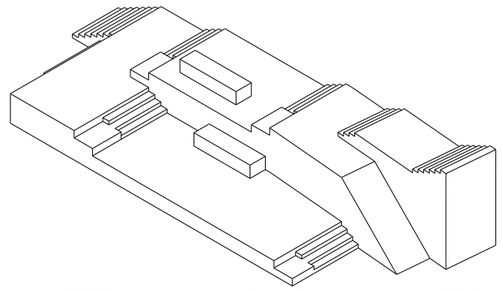
The second iteration was, like the first, split in two. The northern part connected the first and ground floor, with ample space in it for kids to play on. The functionality of it builds around a few play activities and seating areas. Placing slides and benches for such purposes. The second is made to be an amphitheater-like construction. This was for the inclusion of certain events or just general seating purposes.

Generally, the ideas of this version carried over to the final iteration, however, with the removal of the nook the amphitheater needed to become part of the main body. Additionally, we needed to add functionality, so the heights were changed to allow the second to the lowest platform to be used as a table by the elders, and the lowest by the kids. We added a climbing wall and shelves for toys so the kids could play. The amphitheater became the end of the construction. With all these elements, we had made an area where the kids will play, drawing the elders' attention. When the elders enter the area, they have the opportunity to engage the children in conversation or play, thereby creating the bonds that will lead to social betterment.

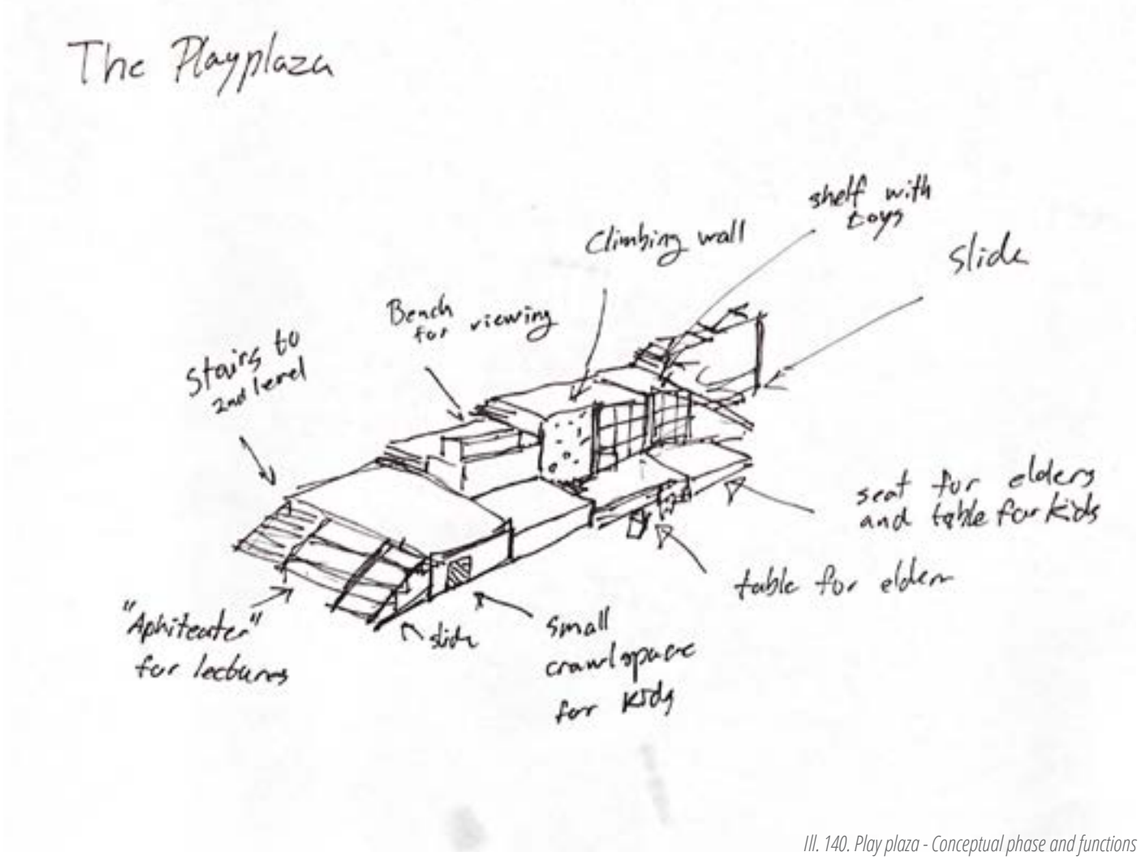




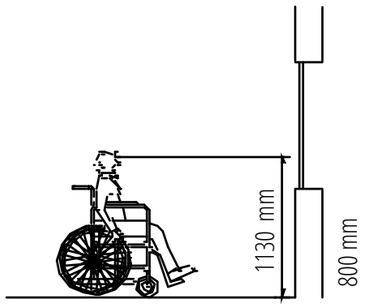
Ill. 141. Final play plaza model



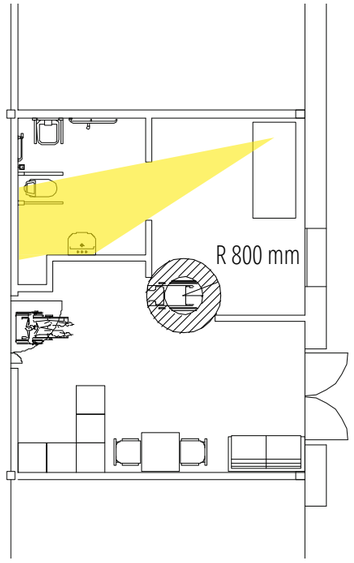
Ill. 142. Midway play plaza model



Ill. 140. Play plaza - Conceptual phase and functions



Ill. 143. Ensuring visual access to the nature while in sedentary position



Ill. 144. Apartment qualities

Ease of movement while in wheelchair

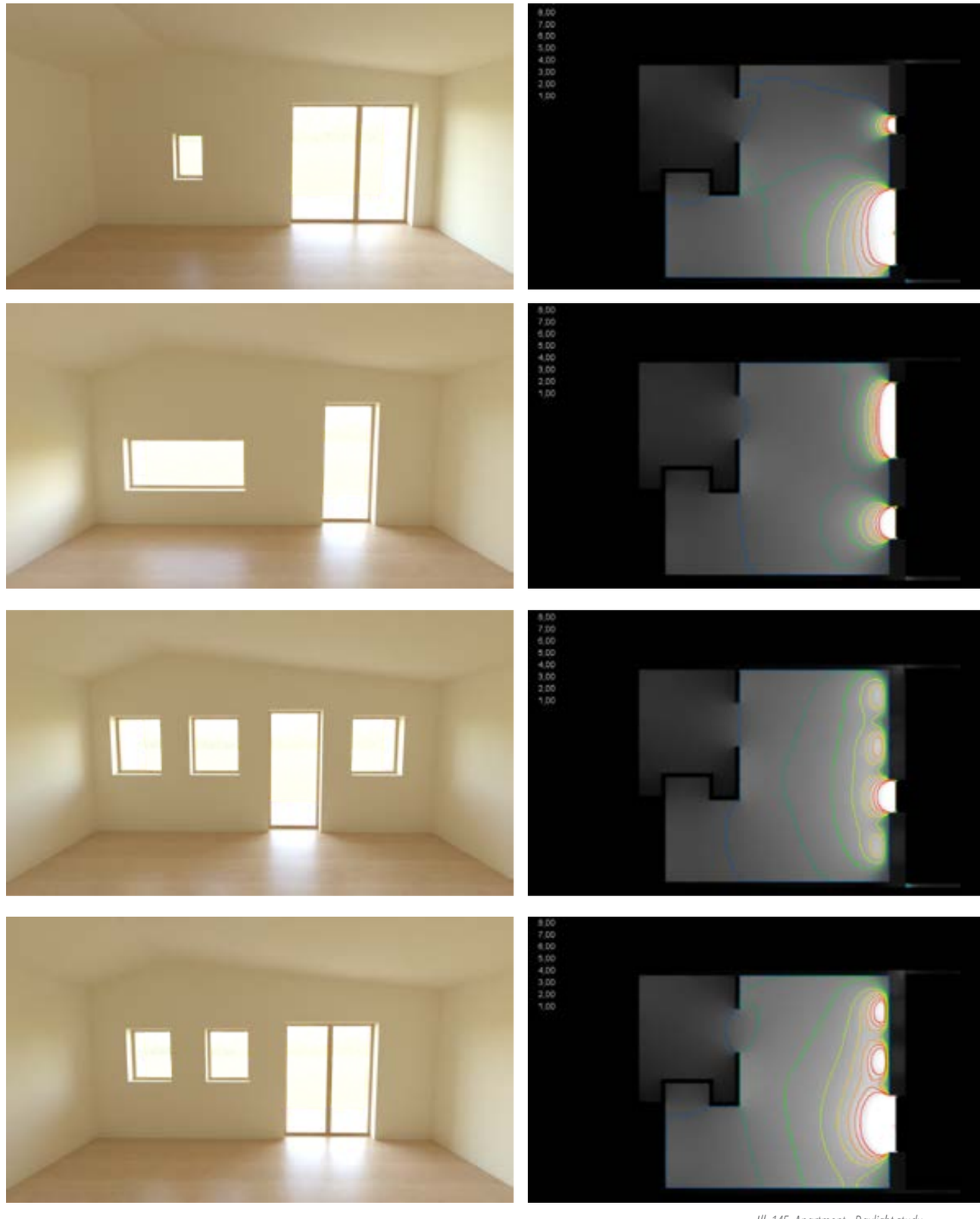
Sufficient space for rotation of carriage bed

Toilet is visible from bed and directly accessible

APARTMENT DEVELOPMENT

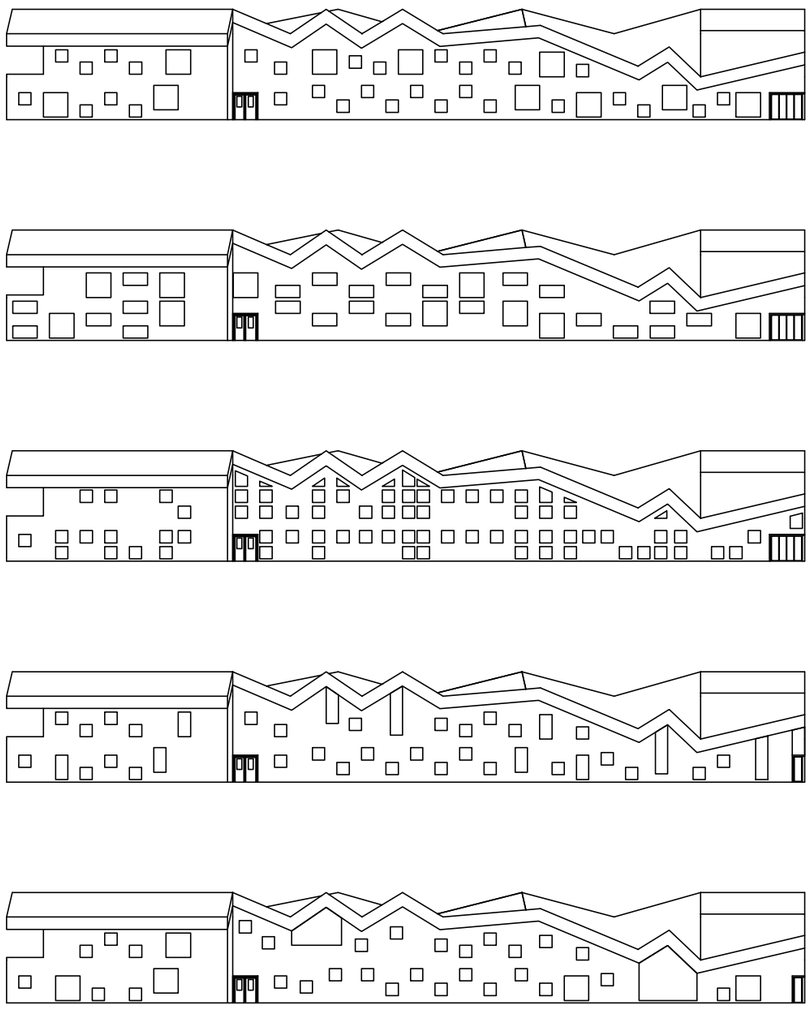
The first step of designing the apartments was finding the established norms and regulations of these types of rooms. For this, we talked to a working architect and looked through the Danish direction for nursing homes for people with dementia. Although our project does not include people who are suffering from dementia it is a helpful guide for the general needs of people living in nursing homes. Then we looked at the general layouts of several of these kinds of apartments. We did this to generate a library of general solutions that were already in use. Our general setup for the apartment was established through methods.

Our general evolution of apartments builds on improving the living spaces for them by giving them more of what would be in a general apartment. With all choices, it's a give-and-take. One of the first things has been to make a daylight study for the initial apartment plan, in which the target was to find out the area of m^2 required to provide sufficient daylight and explore ways of positioning the openings. On the next phase, we sought to increase the size of the living space; however, this pursuit of the interior space came at the cost of the indentations in the hallway. These indentations would have provided an identity for the individual units. Additionally, we elected to divide the spaces in between the living room and bedroom. To allow for ephemeral interaction that could take place in these indentations, we instead increased the hallway area. However, the indentations would allow the rooms to be visibly defined from their outside, and this quality was now lost.



Ill. 145. Apartment - Daylight study

OPENINGS STUDY



Ill. 146. Openings scenarios

The scenarios for the openings constist of one or more shapes and sizes of openings. The desired outcome was, apart from providing sufficient natural light to all indoor areas, to operate as another tool that communicates the co-existance of two different aged groups to the observers of the building. For this reason, the scenarios that have the same shape of windows in different sizes felt more appropriate, in an analogy to the young and grown-up people using the building. Another characterictic we decided to implement was allowing for some of the bigger openings to follow the shape of the roof, to emphasize it even more. Another challenge was that we wanted to create a playful expression, to commucate the process of learning through playing that is going on in the building, while designing on grid, to ensure buildability. For these reasons, it was decided to go with the fifth scenario, Therefore have squared openings of two sizes, placed in different heights, alongside with some openings that follow the roof shape.

NORDIC AESTHETICS IN CLADDING

The building will consist of low-polluting natural materials, as they reduce the environmental footprint of it and are healthier for the users. Here are studied the options for the outdoor and interior look of the building, according to the available solutions that work for the local climate characteristics and available local resources. For a building of natural materials, it is important that the materials are vapor permeable, in order for the materials to be able to use their natural ability to absorb and exude any excessive indoor humidity without developing mould, which would be unhealthy for the users and shorten the lifespan of the materials themselves.

EXTERNAL EXPRESSION

Denmark has a long history in building with wood, clay, and lime, as they are locally available and are reliable as building materials for the local, cold and humid climate. Throughout the years, these materials have been industrialized in order for their performance to improve and for more applications to be developed.

WOOD

Ill. 147. Source: Adam Mørk (2016) Råå Daycare Center

There are several types of trees forested in Denmark that are appropriate for production of timber for facade cladding, with pruce, oak, fir, and beech being the most common. Wood absorbs and exudes moisture and therefore balances the humidity to some extent (Ivanovic-Sekularac et al., 2012). Heat-treated wood is often used for cladding, as this process improves its resistance to wind, moisture, and other climatic phenomena, while it also protects it from pest and rodents. The process of heat-treating the wood poses no harm to the environment. However, solar radiation will still affect the behavior of the wooden elements and fire protection should be applied in the building. An exterior heat-treated timber spruce facade is expected to have a minimum lifespan of 15 years, while the wood can be naturally maintained with resin and, when pieces of the facade are no longer appropriate for use, they can be replaced without damaging the rest of it.

CLAY BRICK

Ill. 148. Source: Unknown photographer (2016) Krøyers Plads

Clay exists in abundance in Denmark and burnt clay brick constructions have been characterizing the local built environment throughout the years. The porousness of bricks depends on the process of their burning and affects their vapor permeability, however, in general, clay bricks are vapor permeable and also have the natural ability to balance the humidity by absorbing and exuding moisture, without rotting (Modern Masonry Alliance, 2016). Additionally, they have great resistance against water and fire, and cannot be penetrated by insects. Their lifespan exceeds the 500 years and if installed with non-adhesive mortar, they can be uninstalled and reused with recuced damages (Claybrick.org, n.d.).

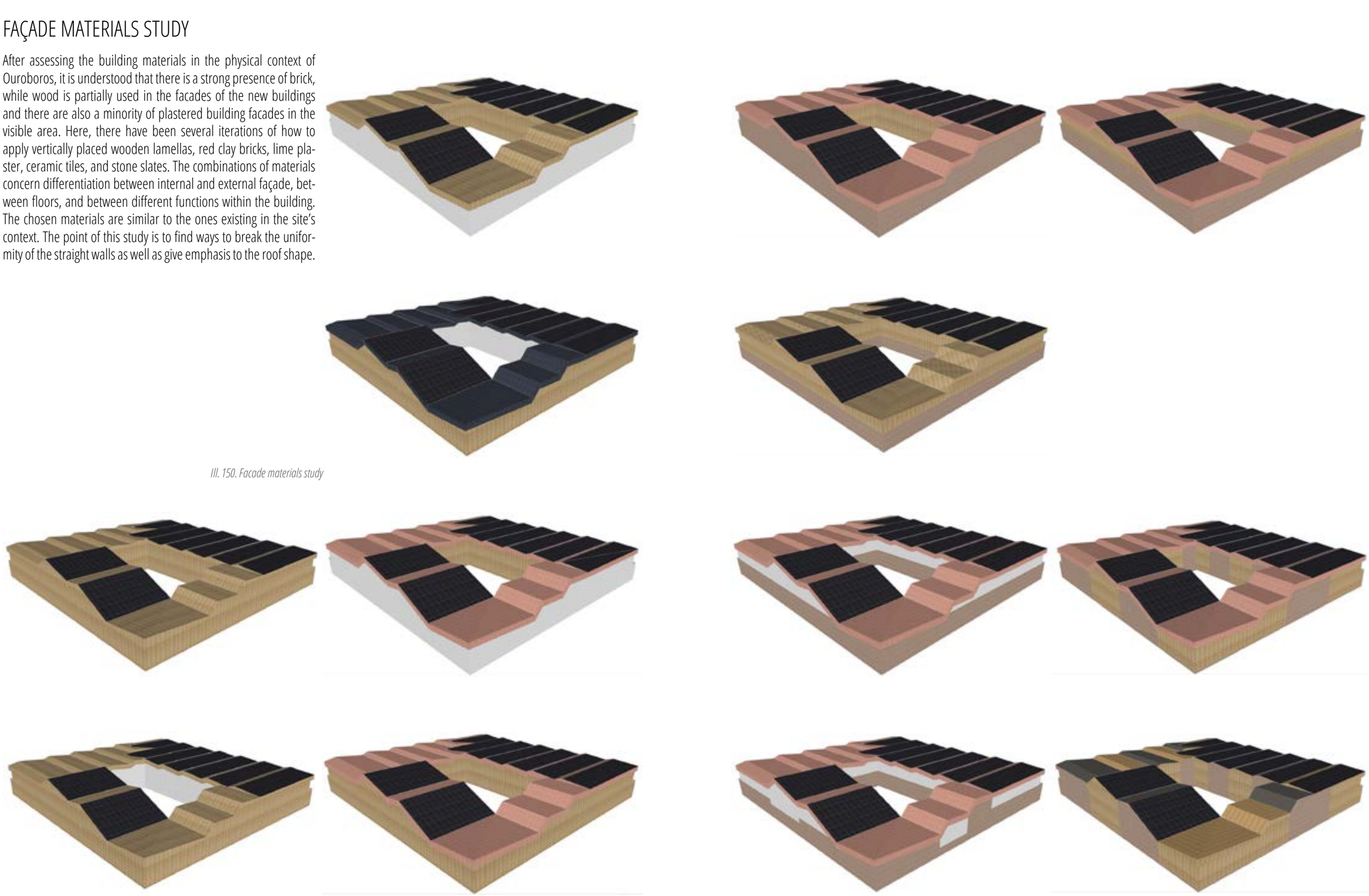
LIME PLASTER

Ill. 149. Source: Hjart (2020) Gammel Haderslev Kirke

Lime is locally available and, as a plaster, it performs great in cold and humid climates (Tŷ-Mawr, 2016). It is recommended for cases where natural materials are to be used for insulation, as it is vapor permeable (Natural Building, 2016). Additionally, it presents some ability in self-healing its own cracks. The cracks can be easily repaired by wetting the surface and filling in with new material in several layers. Naturally, lime does not allow for mould to grow on it and on its nearby elements (Renderitoz.com, 2016). Its lifespan is at minimum of 100 years (GreenSpec, 2020), while in Denmark there can be observed historical buildings, such as churches, that have exterior lime plaster applied for many more years than this. Lime plaster can be recycled, however it is unclear whether this is an environmentally sustainable option or not (Listed Building Surveys, 2018).

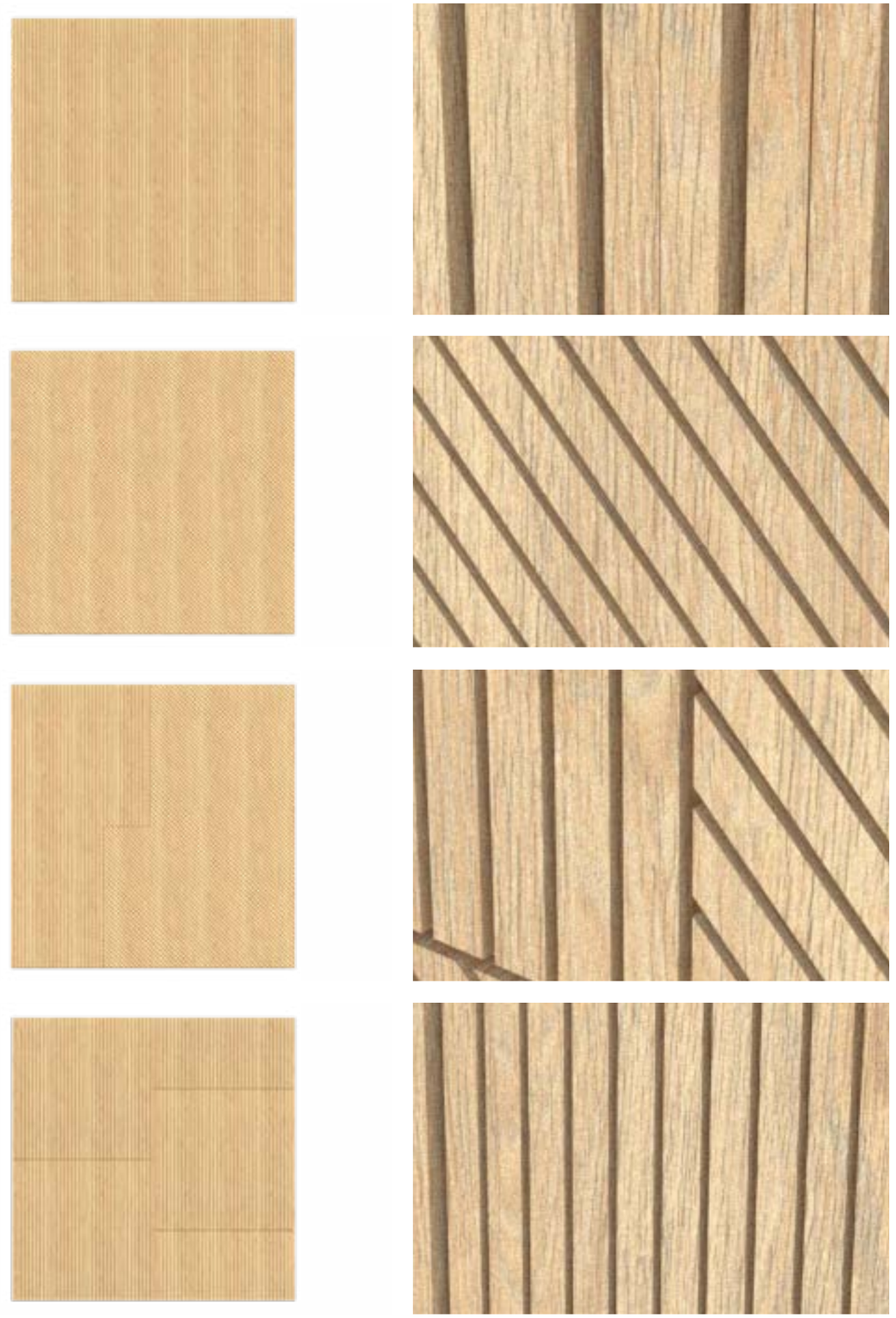
FAÇADE MATERIALS STUDY

After assessing the building materials in the physical context of Ouroboros, it is understood that there is a strong presence of brick, while wood is partially used in the facades of the new buildings and there are also a minority of plastered building facades in the visible area. Here, there have been several iterations of how to apply vertically placed wooden lamellas, red clay bricks, lime plaster, ceramic tiles, and stone slates. The combinations of materials concern differentiation between internal and external façade, between floors, and between different functions within the building. The chosen materials are similar to the ones existing in the site's context. The point of this study is to find ways to break the uniformity of the straight walls as well as give emphasis to the roof shape.



Ill. 150. Facade materials study

The team concluded that the combination of different materials is not providing the desired result, however, through this study, it was observed that breaking the monolithic expression of the building would be an asset for it. Therefore, the next step has been to create scenarios of a façade consisting of wooden lamellas that could have the same effect. The scenarios concern a combination of lamellas placed vertically and diagonally as well as having them overlapping vertically. It has been decided to follow the final scenario, both from a perspective of aesthetic expression and because, in real life, it would require less editing in the shape of the lamellas, allowing them to have a bigger recycling potential.

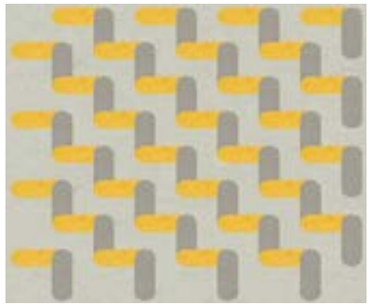


Ill. 151. Facade - wood detailing

INTERIOR FINISH MATERIAL PALETTE

Ill. 153. Fir wood, Source: https://dinesen-europe-cdn.azureedge.net/media/1664/grandoak_classic_1120x1120_dinesen.jpg?mode=max&width=560

Ill. 154. Parquet floor, Source: https://naturalwoodfloor.co.uk/product/flooring/engineered-flooring/engineered-pre-lacquered/oak-premier-lacquered-210-x-20-mm/



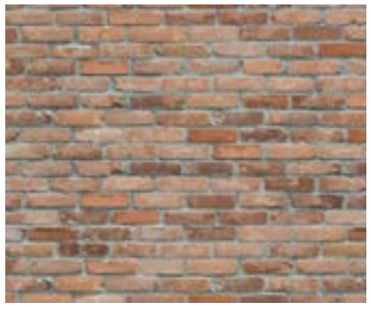
Ill. 155. Linoleum, Source: https://www.forbo.com/flooring/en-gl/products/linoleum/marmoleum-imagine/sigrid-calon/bgowxc#weave__2

Ill. 156. Plywood oak, Source: https://naturalwoodfloor.co.uk/product/flooring/engineered-flooring/engineered-pre-oiled/oak-natural-oiled-135-x-20-mm/

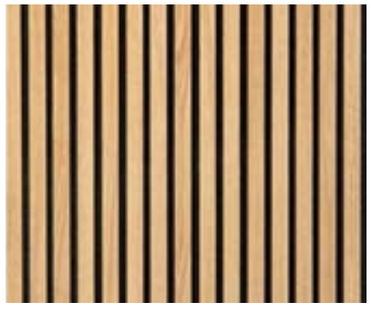
Ill. 157. Clay, rough finish, Source: https://texturebox.com/yellow-plaster-wall-texture

Ill. 158. Clay, rough finish 2, Source: https://www.naturalplastersandiego.com/work?itemId=35yqcar20urka1dvhb0beo8oxdvi2l

Ill. 159. Lime plaster, Source: https://texturebox.com/white-plaster-texture-01



Ill. 160. Red bricks, reclaimed, Source: https://texturebox.com/damaged-brick-texture-01

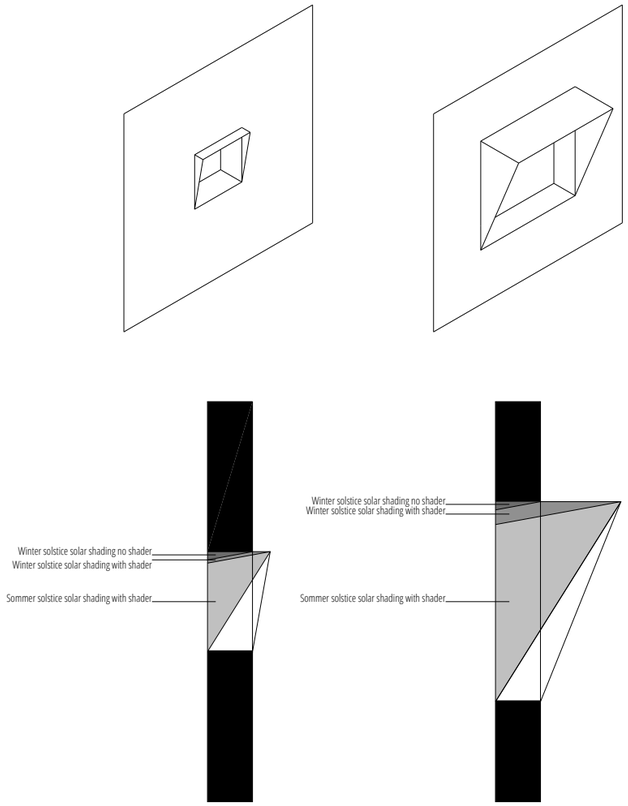


Ill. 161. Wooden lamellas, Source: https://daarbakprodstorage.blob.core.windows.net/variant-images/139975/600x600/7059c098-a2fb-4d3b-8cce-52075b95c597.png

Ill. 152. Material palette

Here are presented the materials that have been considered for interior finishes. The palette includes mostly warm natural materials that provide different tactile experiences. The point has been to combine them so to enhance this difference between them. Additionally, linoleum has been considered as a choice of material for flooring specific areas that are expected to be getting dirty more frequently than others, as it is an easy to clean material, yet it was decided that its expression should not imitate that of a natural material, but instead embrace its possibilities for a unique expression. In the final stage, a less ”noisy” version of linoleum was chosen to match with the rest of the materials, however, still, the imitation of a natural material expression remained to be avoided.

SOLAR SHADING



Ill. 162. Solar shading - Expression

The shading for the windows is designed to create a visual element within the architecture, while not relying on the traditional passive shading strategies. When designing passive shading architects leans towards a singular solution, the overhanging eaves. With this solution, the design and the thermal needs integrate beautifully. However, if the shape language or the height makes these implementations rather hard to incorporate within a cohesive design language. Once the design for Ouroboros began taking shape the building would not be able to fully integrate these kinds of eaves while keeping our vision for the expression. So we sought to change this design disadvantage into an expression defining element. We sought to create some sort of window cases that would shade during the summer while allowing the sun to enter during the winter months. These cases are made so that the summer angle of 57 degrees, adjusted for the angle of the building, hits the back of the recess, and the winter solstice sun still has a 95% and 86.9% efficiency on 1000x1000 mm2 and 2000x2000 mm2 windows respectivey.

1,00 x 1,00 m opening without shading

1,00 x 1,00 m opening with shading

2,00 x 2,00 m opening without shading

2,00 x 2,00 m opening with shading

Ill. 163. Solar shading - Provision to daylight after installment

A	Monocrystalline	Polycrystalline	Amorphouts thin film
Area (m^2)	1	1	1
B			
Efficiency	18	13	9
C = A*B/100			
Installed power	0,18	0,13	0,09
D			
Efficiency factor for optimal integrated system	0,75	0,75	0,75
E			
Solar radiation intensity (kWh/m^2)	1163	1163	1163
Annual yield = C*D*E (kWh/m^2year)	146,538	105,833	73,269
	Monocrystalline	Polycrystalline	Amorphouts thin film
Lifespan (years)	25	20	15

SELECTION OF MAIN ACTIVE STRATEGY

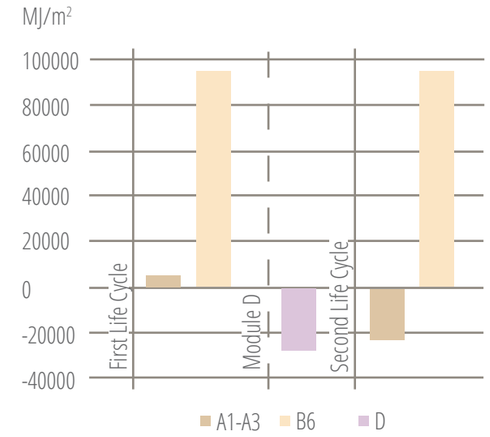
The principals of circular design direct the project to aim to the use of renewable energy sources in order to provide energy for the building. The search on local energy providers concluded that, although Denmark is leading the implementation of renewable energy sources in EU, with 30% of all energy coming from renewable energy sources (Denmark.dk, Pioneers in Clean energy, no date), yet there is no energy provider that can ensure that all of their energy comes from renewable energy sources. For this reason, it has been determined from the beginning of the project that Ouroboros should be appropriately equipped with the tools to provide energy for itself.

An observation of the site characteristics and the possible available energy resources that can potentially be harvested within it led to the conclusion that the most favorable choices should be either the small scale wind turbines or the photovoltaic panels. In this competition, the photovoltaic panels appear to be more appropriate for the case, as the site gets no shadows from its surroundings, while additionally the panels can be integrated onto the building and become part of its aesthetic expression. On the contrary, small scale wind turbines may still be efficient and able to get integrated onto the building, however, they still give the essence of an additive instead of an original part that expresses the overall aesthetic of the building, while moreover, they can create noise. Finally, according to the available EPD data on Oekobaudat.de, PV panels appear to be circular, on the term that they are able to be recycled and this process can potentially be beneficial for the resulted products, regarding their embodied energy and carbon footprint, while the wind turbine components are hardly being reused and the process of recycling them currently is unsustainable to the point that their EPD includes no value for their recycling potential.

The comparison of the energy provided by each type of available PV panels follows above. The final choice will happen in relevance to the efficiency of the panels, as well as their expected lifespan duration. The functional unit is 1 m^2 of PV panels that are oriented to face the South on a degree of 45^o, as this positioning is the most efficient for PV panels in Denmark. A limitation is that the price of the panels has been excluded from the parameters that will determine the final choice. According to the calculations, the chosen panels to be installed will be the monocrystalline silicon panels, as they are the most efficient and have the biggest lifespan, and therefore provide more energy during their life cycle.

LIFE CYCLE ASSESSMENT OF THE PV PANELS IN MULTIPLE LIFE CYCLES

The choice of using renewable energy resources is logical through the prism of the circular economy principals, in the sense that every product should strive for getting the energy it requires to operate from resources that are not finite, to avoid resource depletion. However, it is known that the efficiency of the current renewable energy technologies is sometimes not ideal, although the progress is rapid. A great example of this is the photovoltaic panels, which, in their most efficient form, the monocrystalline silicon panels, have an efficiency of 18%, by the time they are installed. Moreover, there has to be considered that the PV panels have a degradation rate concerning their efficiency, which, in 2012, was considered to be 0,8%, however, through the research and application of new technologies, currently this rate is considered to be 0,5% per year, while there are companies that insist that they have managed to manufacture PV panels with degradation rates of 0,3% per year (L. Richarson, 2019).



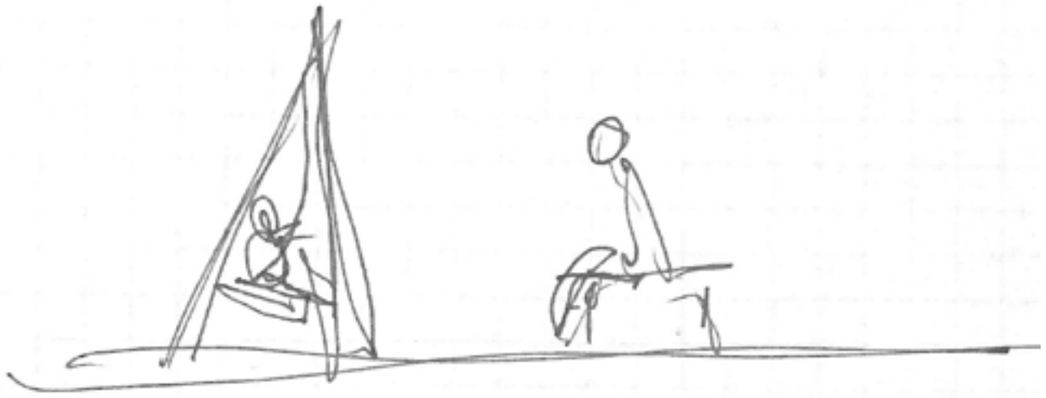
Considering these facts, it is evident that the focus should be given to upgrading the technologies related to renewable energy, however, in terms of sustainability, meaning that the current way of life cannot compromise the quality of the future life, it is important to investigate whether using photovoltaic panels in their current form is a responsible, sustainable solution.

The way to draw some conclusions for this topic is happening here through life cycle assessment. The EPD used for the assessment comes from Oekobaudat.de and concerns a photovoltaic system of 1200 kWh/m^2 x a and has a functional unit of 1 m^2, while it considers the life cycle of the panel to be 20 years. The assessment considers the energy required for this product to be produced in relation to the energy that it produces while in use.

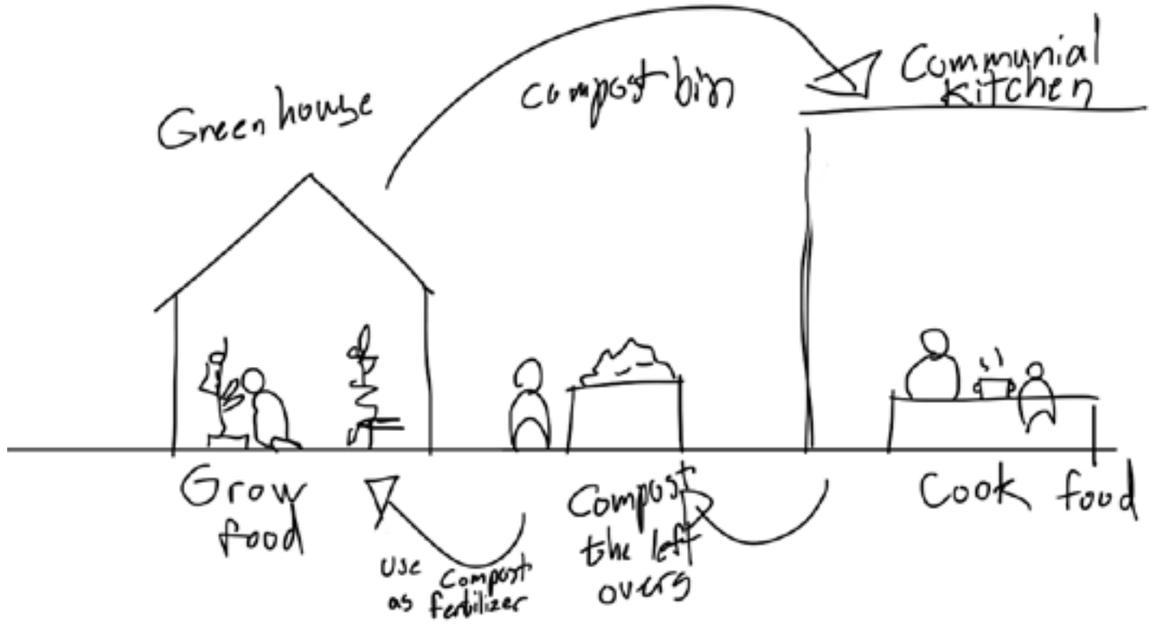
	A1-A3	B6	C4	D
PERE (MJ)	993,5	95000	20,26	-10900
PENRE (MJ)	3913	0	73,02	-16600
NRSF (MJ)	0	0	0	0
RSF (MJ)	0	0	0	0
Total (MJ)	4906,5	95040	93,28	-27500

The findings show that the Operational energy use, which is expressed through B6 of the Use Stage in life cycle assessment, outweighs the energy required in its Product Stage A1-A3, which expresses the energy required for the raw material to be harvested and manufactured into a PV panel of 1 m^2. Moreover, the silicon-based PV panels are truly circular, as they are still efficient after their recommended life cycle, therefore reduce the need for new products, but also can be processed in order for their components to be reused. At least 80% of each material consisting the silicon-based PV panels can be reused (Y. Doff, 2020), and therefore it is logical that the assessed EPD includes the recycling potential of the given panel in Module D, although it estimates a rather optimistic scenario than that of reusing 80% of the included materials (Appendix 8: Life cycle assessment of PV panels). The conclusion is that, not only silicon-based PV panels are a sustainable choice for renewable energy use, but additionally, as they are a circular product, they provide benefits for their future life cycle.

	A1-A3 (MJ/m^2)
1st life cycle	4906,5
2nd life cycle	-22593,5



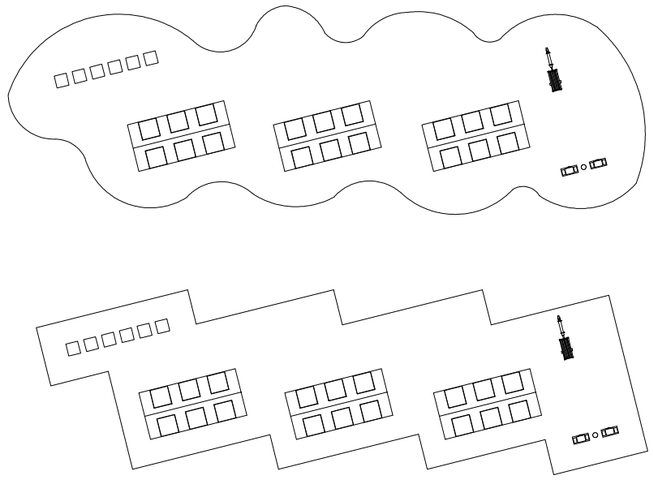
Ill. 164. Principal sketch of social interaction outdoors



Ill. 166. Principal sketch for relation between circular activities

OUTDOOR AREA FORMATION

The main goal for the outdoor space was to bring this intergenerational activity outdoors and providing both educational and recreational activities. The thought of implementing the circular activities of cooking, gardening, and composting together has been from the beginning in mind, as it revolves around activities that both user groups can participate in a way, while the participation should result for the users to enjoy their time while learning. However, the site is spacious enough to also include activities that are only for one of the user groups. In this case, Jan Gehl's theory about passive interaction drove the design to think of ways to encourage users to remain in visual contact while sitting outside. The next thought was about increasing the flora in the site, as the contact with nature should result in calming effects for all users, while it may also provide learning opportunities for the kids. There has been a discussion on how the paved areas should be shaped, as the building is quite orthogonal, while nature is not. For this reason, it was decided that the pavement around the building should follow the shape language of the building, while the pavement crossing nature should follow the shape language of nature.



Ill. 165. Expression of paved outdoor area

FINAL THOUGHTS

Discussion
Conclusion
Reflectioin

OLD VS NEW BUILDING

During this entire project, we have made two distinct projects trying to solve the questions we asked ourselves less than a year ago. How does one create a circular building which facilitates a symbiotic relationship between childcare and eldercare? And what benefit can be created through an intergenerational facility? And does architecture change when designed based on the circular culture? Through this, we have made two different proposals. We would now like to examine the fundamental differences in how these projects answer our original questions. For convenience's sake, we will be referring to the old project as the Old and the new as the New.

The first part we would like to discuss is how do these projects differ in their handling of the symbiotic relationship? Firstly, the theory of what happens in the users psychologically is the same for both projects. They both try to utilize the inherent benefit of these people interacting, however, the way these buildings use it is fundamentally different. The Old seeks to unify the users by having a central area where they can meet. Additionally, it preserves the autonomy of the two types of care-taking facilities, by making them separate autonomous functions, only when double functionality is obvious is it implemented. Contrary to the Old the New seeks to unify the users by placing them in proximity while creating the barrier of the two-story division. This allows the elders to passively interact with the kids while maintaining their private sphere. Additionally, the building has no clear distinct division between the two institutions, making cohesion in the facility type. The cohesion in the New is far greater, it seems as complete whole compared to the fragmented layout of the Old.

The technical solution and their implementation into the design are completely different between the Old and the New. The old had a superficial implementation of the DFD principles. It didn't design any solutions on how to disassemble the different parts of the construction and envelope. Additionally, these supposed qualities were never shown to the users, inside or outside. However, the new seeks to implement these solutions into the aesthetical expression of the building. Having visibly disassemblable wall panels clues the users into the nature of the construction. Creating an honest piece of architecture. Additionally, the way the disassemble the building is much clearer, with steps of different construction-levels. By properly utilizing the technical knowledge into the design phase the New incorporates the ideas of DfD into its identity. Additionally, the sustainability approach by the New quite outshines the Old. The Old relied upon active strategies to ensure its sustainability, while the New utilizes passive initiatives to reduce the overall environmental load before adding its active strategies.

The function design between these projects is in opposite directions in terms of philosophy. While the Old had a generalized view that the functions in practice are unknowable and therefore had to change during its lifecycle. This led to a general design without any considerations towards the conditions these activities needed. In contrast, the New has its functions divided into purpose-built spaces. The New philosophy towards these spaces is that they should be able to serve the needs of the present and through DfD change if needed in the future.

A fundamental difference between the two projects has been clear. The New utilizes its social resources in a purposeful and directed manner, while the Old tries to achieve these through unfocused efforts.

SPATIAL RECYCLING DESIGN: A DISCUSSION

When designing buildings for DfD, a secondary strategy can emerge to complement the DfD design. This strategy is to design the building with a layout and structure, that can be retrofitted into other functionalities. We elected to name this strategy Spatial Recycling Design, or SRD for short. This strategy would allow future users, with minimal changes, to completely change the building's function, thereby recycling the space for a new purpose. In Ouroboros, SRD manifested into the project in the form of the orthogonal pillar system and non-load-bearing walls. These would allow future users to tear down any walls and completely repurpose the building. However, when deciding to implement strategies into a design process work resources, time, have to be allocated towards it. If going under the assumption that within any given project the resources are finite, that would mean that when choosing to implement such a strategy resources have to be allocated from elsewhere in the project. Not to say that choosing to use any form of strategy is a bad thing. It is what gives buildings' their unique qualities. The problem is that with future-dependent strategies, such as SRD and DfD, the success of them is non-deterministic. Utilizing DfD and SRD in the design phase allows for future designers and contractors to easily transform and disassemble the building. However, this is a non-certainty. These design strategies are only successful if the intentions of the designers are met in the future. So in a way, while designing buildings like this we, as designers, are allocating resources into processes and strategies that might never come to fruition. Ouroboros might never have to change its functionality. So the big question is, should we, as designers, have been spending our time on parts of the project that had deterministic value? SRD had a lot of sway over the overall spatial syntax of the building. Would we have made a better intergenerational facility if not constrained by these strategies? Of course, that is unknowable in the end, however, it is our core belief that architecture needs to consider its long-term effects. Architecture needs to become future-proof. By utilizing strategies like these, the building becomes able to adapt and change to the needs of the future. Because architecture far outlives its technical and functional viability, a malleable design framework within the design parameters allows the building to change and extend its functional and technical competency. Of course, these strategies shouldn't be omnipresent. A designer should always consider what and how they implement any sort of strategy. A design implementation always comes with pros and cons, it's the designer's responsibility to use each for their full effect.

CONCLUSION

Ouroboros as a project sought to find a solution to whether or not circular principles could be implemented into the social aspects of a building design. To prove this we explored the particular relationship between elders and children. We tried to design and build on the relatively new building typology, intergenerational facility. To this end, we uncovered certain principles that lay as the foundation of our interpretation of it. Firstly, the unity of the building must be high to ensure the contact between users is established. Secondly, boundaries must be clearly defined to ensure that the elders' self is maintained. Thirdly, the designer needs to establish a design for passive interaction, as described by Jan Gehl. This is to ensure that the elders are enticed to seek out and create a bond between them. We believe that through the spatial recommendation of Min-Young Seo we have sufficient justification for our design philosophy. However, it is unknowable whether or not this social experiment is successful or not. The building needs to be build to verify our hypothesis in this regard. This is the exact reason that DFD is a vital part of our overall strategy. With a malleable design framework, the project becomes a lower risk to any potential building owner. If this particular form of intergenerational facility is a detriment for the users, the building owner could easily transform, disassemble, or reconfigure the building for another use.

The core of designing an intergenerational facility is shared activity areas. These areas should allow for a multitude of intimacy levels so that organic interaction can occur. Although planned interaction is needed to kickstart the interaction between the user groups, it is vital that the building is designed around organic interactions.

The architecture seeks to implement the principles in circular thinking into a social and environmental context. This is achieved through the combining of the two user groups, whom both suffer from limited interaction in their care-taking facilities, and the designing the building for disassembly with the use of low carbon footprint materials. By doing this we create a holistic building which creates future benefit both environmentally and socially.

REFLECTION

Designing an intergenerational facility turned out to be a tremendous task with a bunch of problematic design tasks. Firstly, the constant problem of how much to integrate the different users occupied a lot of the discussion during the entire project. We believe that the right amount of integration is different from project to project. If we had elected to house 50 elders, from early on in the design process, it would have necessitated a different kind of unity between the users. In this scenario, we would likely have made satellite elder groups who would connect to a larger facility. The biggest hurdle for us in this process was to maintain the functionality of the facility while giving the users to interact.

The development of the outdoor areas has been lacking compared to the internal development. The outdoor area could have played a larger part in the overall concept of the interaction plan. If planned out meeting spots had been integrated into the plan the outside could play a supportive role in ensuring the development of these users.

The DfD, which played a vital role in ensuring the viability of our proposal, could have been handled differently. It had a large control over the overall possibilities in shape and material choices. If given lesser importance in the project, we would have been freer to explore more organic solutions. Additionally, the DfD caused us to cut some studies, we didn't have time to implement. Originally we wanted to explore the acoustic indoor environment of the building, to ensure that not too much noise was generated. However, because of DfD being more demanding than initially anticipated, we had to cut these studies for time. This, however, led to another development, in our interchangeable wall paneling system. We believed that if we couldn't do actual acoustic simulations, we would allow the building to change the acoustic qualities over time. By making a system where the users can change panels with ease, would allow them, when built, to adapt to the actual conditions.

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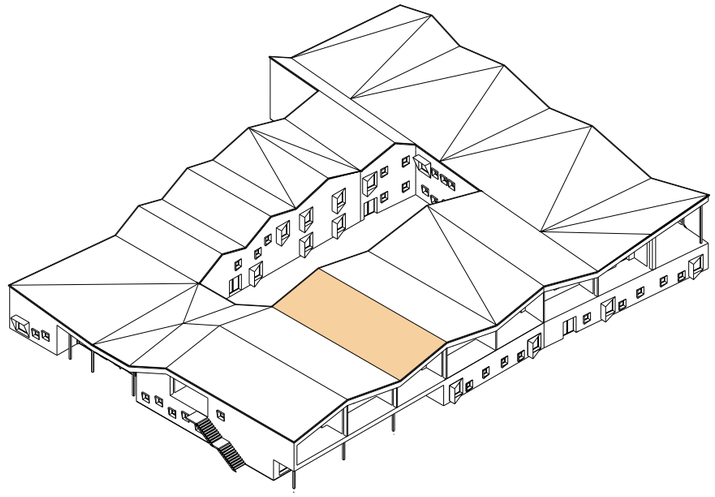
APPENDIX 1: THERMAL TRANSMITTANCE

One of the main passive strategies implemented in the building was the creation of a building envelope of U-value below 0,1 W/m^{2}K. At the same time, the thickness of the wall needed to be reasonable, as the additional materials are costy and also can descrease the available indoor space. The majority of the envelope composites perform sufficiently. The joining element between walls performs worse than 0,1 W/m^{2}K at its most critical area, however this has been expected.

Exterior walls: thickness = 0,497 m, U-value = 0,083 W/m^{2}K,
Roof: thickness = 0,657 m, U-value = 0,066 W/m^{2}K,
Slabs: thickness = 0,692 m, U-value = 0,07 W/m^{2}K
Wall-to-wall joining element: U-value = 0,19 W/m^{2}K

Exterior wall (Timber frame with cellulose insulation)	Lambda λ (W/mK)	Thickness D (m)	R=D/λ (m²K/W)	U-value (W/m²K)
Larch timber cladding	0,13	0,028	0,215384615	
Horizontal battens 30x40	0,14	0,03	0,214285714	
Vertical slats 30x40	0,14	0,03	0,214285714	
Wood fibre board windshield	0,048	0,024	0,5	
Cellulose insulation	0,04	0,35	8,75	
Battens 30x40	0,14	0,03	0,214285714	
Clay board	0,013	0,025	1,923076923	
Clay plaster	0,095	0,01	0,105263158	
		0,527	12,13658184	
Total:		0,497	11,92229612	0,08269728
Roof (Cellulose insulation and seaweed thatch panel)	Lambda λ (W/mK)	Thickness D (m)	R=D/λ (m²K/W)	U-value (W/m²K)
Seaweed thatch panel	0,055	0,2	3,636363636	
Horizontal battens 30x40	0,14	0,03	0,214285714	
Vertical slats 30x40	0,14	0,03	0,214285714	
Wood fibre board	0,048	0,012	0,25	
Cellulose insulation	0,04	0,35	8,75	
Rafter 120x120	0,14	0,12	0,857142857	
Clay board	0,013	0,025	1,923076923	
Clay plaster	0,095	0,01	0,105263158	
		0,777	15,950418	0,06203313
Total:		0,657	15,09327515	0,06551673
Bottom slab (Cellulose and hemp insulation)	Lambda λ (W/mK)	Thickness D (m)	R=D/λ (m²K/W)	U-value (W/m²K)
OSB board	0,13	0,22	1,692307692	
Cellulose insulation	0,04	0,35	8,75	
OSB board	0,013	0,018	1,384615385	
Hemp wool insulation	0,039	0,08	2,051282051	
Wood fibre board	0,048	0,012	0,25	
Larch timber flooring	0,13	0,012	0,092307692	
Total:		0,692	14,22051282	0,06949022
Wall-to-wall connection element	Lambda λ (W/mK)	Thickness D (m)	R=D/λ (m²K/W)	U-value (W/m²K)
Larch timber cladding	0,13	0,028	0,215384615	
Horizontal battens 30x40	0,14	0,03	0,214285714	
Vertical slats 30x40	0,14	0,03	0,214285714	
Wood fibre board windshield	0,048	0,024	0,5	
Cellulose insulation	0,04	0,0065	0,1625	
Battens 30x40	0,14	0,26	1,857142857	
Clay board	0,013	0,025	1,923076923	
Clay plaster	0,095	0,01	0,105263158	
		0,4135	5,191938982	
Total:		0,4135	5,191938982	0,19260627

APPENDIX 2: PHOTOVOLTAIC PANELS

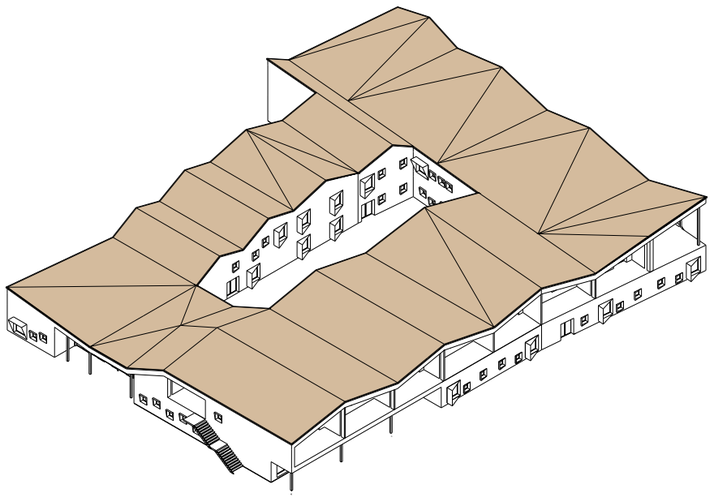


The comparison of the available PV panel options regarding their efficiency and lifespan, determined that monocrystalline silicon PV panels are to be installed to the building, as they present the highest efficiency among PV panels and have a lifespan of 25 years.

A: Total module area = 139 m^2
B: Module efficiency = 15%
C: Installed power (kWpeak) = A*B/100 = 20,85 kWpeak
D:Evaluation of system factor = 0,75
E: Solar radiation intensity = for Southern roof rotated 15^0 and inclined 12^0 = 1090,5 kWh/m^2
F: Annual yield = C*D*E = 17052,69 kWh/year

The installation of the PV panels makes the building a Zero Energy Building.

APPENDIX 3: RAINWATER HARVESTING



Collectable water area = total roof area = 2135 m^2

Average annual rainfall in Denmark (2006 - 2015) = 792 mm

Rainfall in roof area = 1690,92 m^3/year
= 1690920 Lt/year
Consideration of 20% water loss = 1352736 Lt/year

Number of users: 133
24hr/day users: 16
10hr/day users: 117

Average number of toilet uses per 24h user = 4,42

Average Lt per use = 5 Lt
Average Lt per 1 24h user per day = 22,1 Lt
Average Lt per 1 10h user per day (28%) = 6,188 Lt

Demand for 24h users per day = 22,1 x 16 = 353,6 Lt
Demand for 10h users per day = 6,188 x 117 = 723,996 Lt
Demand for 24h users per year = 353,6 x 365 = 129064 Lt
Demand for 10h users per year = 723,996 x 365 = 264258,5 Lt
Total annual demand for toilet use = 393322,5 Lt

Therefore there is greywater sufficiency for toilet use plus:
1690920 - 393322,5 = 959413,5 Lt/year available for washing machine use and irrigation.

APPENDIX 4: MECHANICAL VENTILATION

Air flow rate calculation for a kids' group room and an elder's apartment.

The required ventilation rate is calculated based on the sensory pollution and CO_2 load, in order to determine the mechanical ventilation requirement to achieve atmospheric comfort.

Required ventilation rate (l/s) : $$Q_c = 10 \times \frac{G_c}{c_{ci} - c_{co}} \times \frac{1}{\varepsilon_v}$$

Sensory pollution load caused by building:

$$G_c = 0{,}1 \times \frac{olf}{m^2 floor}$$

Sensory load per activity:

Sedentary person: 1 olf
Children, kindergarten (3-6 yo): 1,2 olf

People load per room:

Group room: 17 people
Apartment: 2 people

Sensory loads:

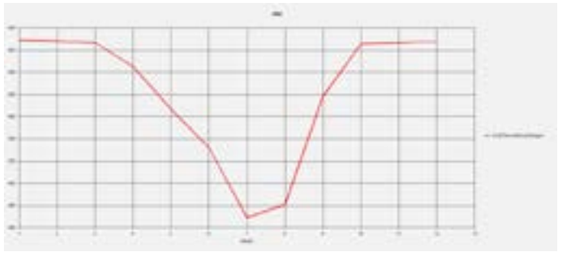
Group room: G_c = 0,1 x 1,2 x 17 / 57,95 = 0,035 olf
Apartment: G_c = 0,1 x 2 / 43,73 = 0,005 olf

Desired perceived indoor quality (dp) : c_{ci} = 1 dp
Perceived outdoor quality (dp): c_{co} = 0,1 dp
Ventilation effectiveness: ε_v = 1

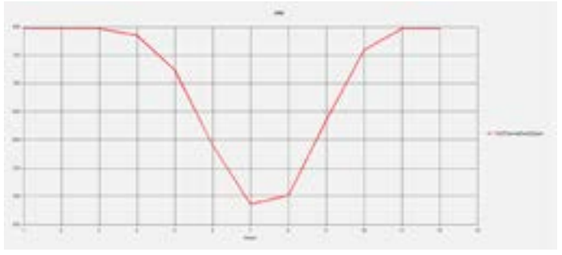
Required ventilation rate for the Group room: Q_c = 10 x (0,035/(1-0,1)) x1/1= 0,039 l/s = 0,000039 m^3/s

Required ventilation rate for Apartment: Q_c = 10 x (0,005/(1-0,1)) x1/1= 0,0055 l/s = 0,0000055 m^3/s

APPENDIX 5: BSIM

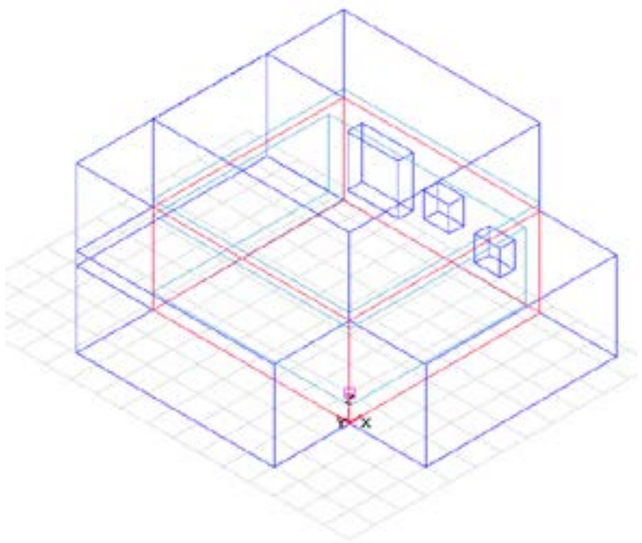


Ill. 282. CO2 concentration per year in kids' group room

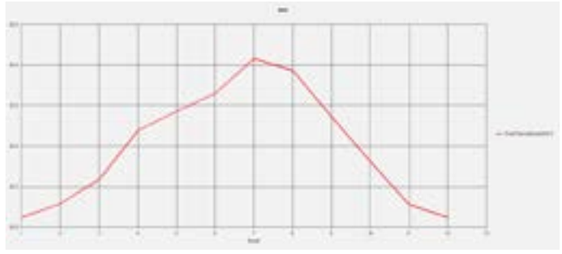


Ill. 283. CO2 concentration per year in elder's apartment

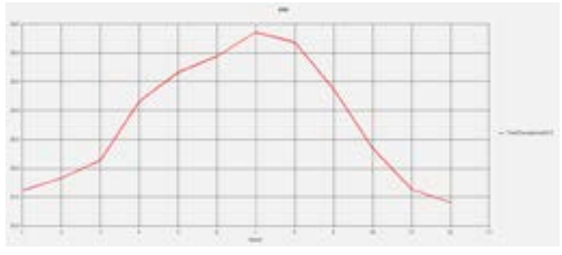
Regarding atmospheric comfort, the concentration of carbon dioxide (CO2) and sensory pollution (olf) have been calculated for one of the kids' group rooms and one of the apartments. To achieve improved atmospheric comfort, the people load in the kids' group room has been considered as 17 people maximum, with 100% of them being in the room every morning between 08:00 – 09:00 and 65% of them being in the room between 09:00 – 17:00, although it is expected that kids will be spending more time daily in other areas of the building. The people load in the elder's apartment has been again calculated in an adverse scenario, where there are 2 people in the room, of which, one is the elder, who is there 24h/day, while the second person is a nurse that comes 3 times per day for one hour to take care of the elder. For these scenarios, the mean air change required for the group room to have CO2 concentration of 629 ppm in the kids' group room and for the apartment to have 797 ppm, is 1,8 l/s and 1,1 l/s respectively, while the mean CO2 concentration is 583 ppm and 706,1 ppm.



Ill. 284. BSim model of group room

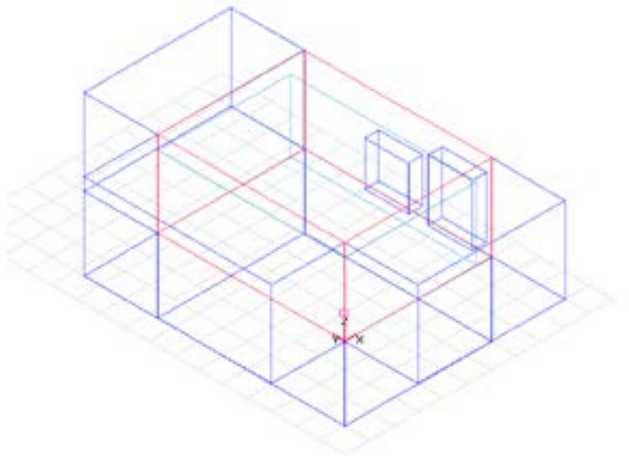


Ill. 285. Temperature range per year in kids' group room



Ill. 286. Temperature range in elder's apartment

The areas that have been considered critical regarding thermal comfort are one of the group rooms and one of the apartments facing to the southeast and being surrounded by building mass, as they have been considered prone to overheating. The simulation showed that the group room has temperature below 20 °C for zero hours, while for 103 hours the temperature is above 26 °C and for 36 hours, the temperature is above 36 °C annually. The apartment has zero hours below 20 °C, while it has 51 hours above 26 °C and 7 hours above 27 °C annually.



Ill. 287. BSim model of apartment

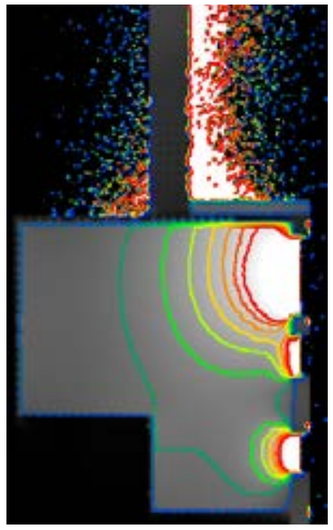
ThermalZon	Sum/Mean	1 [31 days]	2 [28 days]	3 [31 days]	4 [30 days]	5 [31 days]	6 [30 days]	7 [31 days]	8 [31 days]	9 [30 days]	10 [31 days]	11 [30 days]	12 [31 days]
qHeating	0,36	0,02	0,09	0,04	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,11	0,11
qCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qInfiltration	-605,68	-75,08	-68,89	-81,27	-54,13	-40,98	-31,18	-21,17	-20,58	-29,46	-45,01	-63,41	-74,59
qVenting	431,99	-16,81	-15,33	-20,56	-57,19	-89,93	-132,58	-125,35	-113,99	-48,92	-11,81	-13,49	-16,04
qSunRad	1239,84	14,67	34,34	84,16	157,52	185,27	195,94	208,91	170,65	102,16	55,93	18,89	11,39
qPeople	2435,46	206,85	186,83	206,85	200,18	206,85	200,18	206,85	206,85	200,18	206,85	200,18	206,85
qEquipment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qLighting	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qTransmissio	-1081,25	-121,45	-114,66	-129,34	-100,28	-77,77	-63,82	-53,51	-49,67	-56,67	-78,48	-103,71	-121,89
qMixing	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
qVentilation	-1356,74	-8,19	-22,37	-49,87	-146,10	-183,44	-198,54	-215,73	-193,34	-167,29	-127,47	-38,57	-5,83
Sum	0,00	-0,00	0,00	0,00	0,00	0,00	-0,00	0,00	-0,00	0,00	0,00	-0,00	-0,00
tOutdoor me	8,1	0,7	0,4	-0,7	7,1	11,5	14,2	17,8	17,9	14,5	9,8	3,4	0,7
tOp mean[°C	23,0	22,1	22,3	22,6	23,1	23,4	23,6	24,0	23,8	23,3	22,8	22,3	22,1
AirChange[/	1,8	1,4	1,4	1,4	1,5	1,7	2,1	3,2	3,8	1,7	1,4	1,4	1,4
Rel. Moistur	43,3	36,2	35,6	32,4	36,4	41,7	50,1	55,2	53,9	51,6	49,0	40,5	37,6
Co2[ppm]	593,0	629,0	629,2	626,7	606,2	566,9	532,0	469,0	490,8	579,3	625,6	626,5	629,0
PAQ[-]	0,3	0,4	0,4	0,4	0,4	0,3	0,1	0,0	0,0	0,1	0,2	0,3	0,4
Hours > 21	6760	744	672	744	720	744	720	744	744	720	744	720	744
Hours > 26	103	0	0	0	0	0	9	46	42	6	0	0	0
Hours > 27	36	0	0	0	0	0	1	18	12	5	0	0	0
Hours < 20	0	0	0	0	0	0	0	0	0	0	0	0	0
FanPow	1056,11	77,59	70,08	77,59	75,09	77,66	91,60	139,35	134,91	81,99	77,59	75,09	77,59
HtRec	5508,15	794,03	723,38	847,20	480,11	301,63	187,82	82,99	83,83	181,26	385,98	649,12	790,80
ClRec	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
HtCoil	739,14	147,30	125,94	132,96	51,38	20,11	8,27	0,47	0,91	10,01	44,62	110,88	146,56
ClCoil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Humidif	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
FloorHeat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
FloorCool	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentHeatPu	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentHeatPu	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
CentCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00

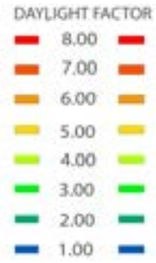
Ill. 288. Results for group room

ThermalZon	Sum/Mean	1 [31 days]	2 [28 days]	3 [31 days]	4 [30 days]	5 [31 days]	6 [30 days]	7 [31 days]	8 [31 days]	9 [30 days]	10 [31 days]	11 [30 days]	12 [31 days]
qHeating	1,69	0,10	0,00	0,07	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,16	1,37
qCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
qInfiltration	-313,45	-38,32	-35,27	-41,70	-28,36	-21,34	-16,86	-11,59	-11,35	-15,52	-22,76	-32,05	-37,73
qVenting	-112,30	0,00	0,00	0,00	-4,14	-18,69	-27,90	-36,97	-22,50	-2,07	-3,03	0,00	0,00
qSunRad	707,45	9,00	21,71	52,99	85,32	102,54	112,08	115,91	91,93	61,32	35,91	11,75	6,98
qPeople	529,25	44,95	40,60	44,95	43,50	44,95	43,50	44,95	44,95	43,50	44,95	43,50	44,95
qEquipment	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
qLighting	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
qTransmissio	-1354,56	-148,70	-142,06	-173,06	-130,60	-109,50	-92,91	-75,84	-70,64	-71,54	-92,35	-116,31	-141,05
qMixing	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
qVentilation	541,92	132,97	115,02	116,75	34,28	2,64	-17,90	-36,47	-32,40	-15,69	24,28	92,95	125,49
Sum	0,00	0,00	0,00	0,00	-0,00	0,00	-0,00	0,00	-0,00	-0,00	-3,00	0,00	0,00
tOutdoor me	8,1	0,7	0,4	-0,7	7,1	11,5	14,2	17,8	17,9	14,5	9,8	3,4	0,7
tOp mean[°C	22,8	21,7	21,9	22,2	23,2	23,7	23,9	24,3	24,2	23,4	22,4	21,7	21,5
AirChange[/	1,1	0,9	1,0	1,0	1,0	1,0	1,3	1,7	1,6	1,2	1,0	1,0	1,0
Rel. Moistur	51,2	46,5	46,1	43,1	47,6	49,8	53,3	55,4	54,3	56,7	50,4	52,6	49,6
Co2[ppm]	705,1	796,9	796,8	796,7	784,6	722,9	593,1	495,7	501,6	634,1	758,6	796,7	796,8
PAQ[-]	0,2	0,3	0,3	0,3	0,2	0,1	0,0	0,0	0,0	0,0	0,1	0,2	0,3
Hours > 21	6711	736	671	742	720	744	720	744	744	720	744	713	713
Hours > 26	51	0	0	0	0	0	7	31	12	1	0	0	0
Hours > 27	7	0	0	0	0	0	0	5	2	0	0	0	0
Hours < 20	0	0	0	0	0	0	0	0	0	0	0	0	0
FanPow	616,18	47,43	42,82	47,38	45,76	48,07	55,26	65,56	65,88	55,99	48,85	45,79	47,38
HtRec	404,73	44,77	41,06	48,29	31,79	24,30	26,70	24,60	24,22	26,65	31,20	37,42	43,73
ClRec	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
HtCoil	590,19	122,70	106,28	109,19	28,56	1,81	2,05	0,33	0,03	2,09	23,59	81,50	115,05
ClCoil	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
Humidif	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
FloorHeat	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
FloorCool	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
CentHeatPu	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
CentCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
CentHeatPu	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00
CentCooling	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	3,00	0,00	0,00

Ill. 289. Results for apartment

APPENDIX 6: DAYLIGHT FACTOR





The daylight factor has been investigated for two critical rooms, this time being one of the apartments facing to the North and the kids' group room that is most shadowed. It is evident that, in both areas, it exceeds the criteria of being above 2% in 50% of the usable area.

APPENDIX 7: BE18

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
95,6	0,0	95,6
Total energy requirement		24,6

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
71,7	0,0	71,7
Total energy requirement		24,6

Energy frame BR 2018

Without supplement	Supplement for special conditions	Total energy frame
41,3	0,0	41,3
Total energy requirement		24,6

Energy frame low energy

Without supplement	Supplement for special conditions	Total energy frame
33,0	0,0	33,0
Total energy requirement		24,6

Contribution to energy requirement

Heat	17,8
El. for operation of bulding	5,0
Excessive in rooms	0,0

Net requirement

Room heating	12,4
Domestic hot water	5,5
Cooling	0,0

Selected electricity requirements

Lighting	1,7
Heating of rooms	0,0
Heating of DHW	0,3
Heat pump	0,0
Ventilators	3,0
Pumps	0,3

Heat loss from installations

Room heating	0,0
Domestic hot water	0,2

Output from special sources

Solar heat	0,0
Heat pump	0,0

Key numbers, kWh/m² year

Renovation class 2

Without supplement	Supplement for special conditions	Total energy frame
95,6	0,0	95,6
Total energy requirement		-0,4

Renovation class 1

Without supplement	Supplement for special conditions	Total energy frame
71,7	0,0	71,7
Total energy requirement		-0,4

Energy frame BR 2018

Without supplement	Supplement for special conditions	Total energy frame
41,3	0,0	41,3
Total energy requirement		-0,4

Energy frame low energy

Without supplement	Supplement for special conditions	Total energy frame
33,0	0,0	33,0
Total energy requirement		-0,4

Contribution to energy requirement

Heat	17,8
El. for operation of bulding	-8,2
Excessive in rooms	0,0

Net requirement

Room heating	12,4
Domestic hot water	5,5
Cooling	0,0

Selected electricity requirements

Lighting	1,7
Heating of rooms	0,0
Heating of DHW	0,3
Heat pump	0,0
Ventilators	3,0
Pumps	0,3

Heat loss from installations

Room heating	0,0
Domestic hot water	0,2

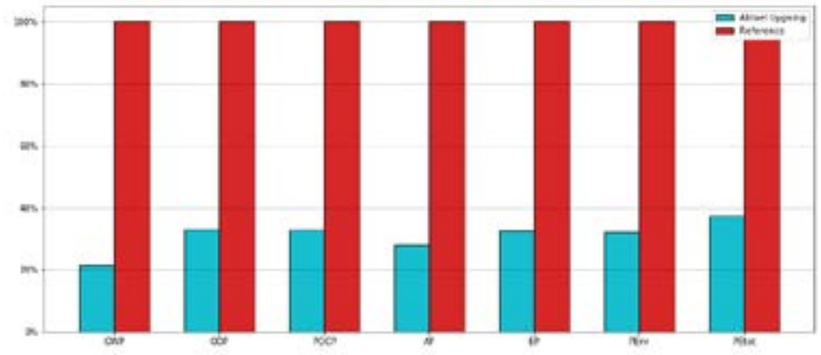
Output from special sources

Solar heat	0,0
Heat pump	0,0

Here is presented the operational energy demand of the building, before and after the implementation of the active strategies. The passive strategies of creating a building envelope of low thermal transmittance, installing hybrid ventilation, arranging the openings according to orientation and adding shadow cases have proven sufficient for bringing the building into the energy frame Low Energy, resulting for it to need 24,6 kWh/m^2year.

The implementation of the photovoltaic panels managed to lower the operational energy demand of the building to -0,4 kWh/m^2year, making it a Zero Energy Building. That means that the building is self-sufficient energy-wise and complies with the target of circular economy in the building sector.

APPENDIX 8: LIFE CYCLE IMPACT ASSESSMENT: DGNB COMPARISON AND OUROBOROS REPORT



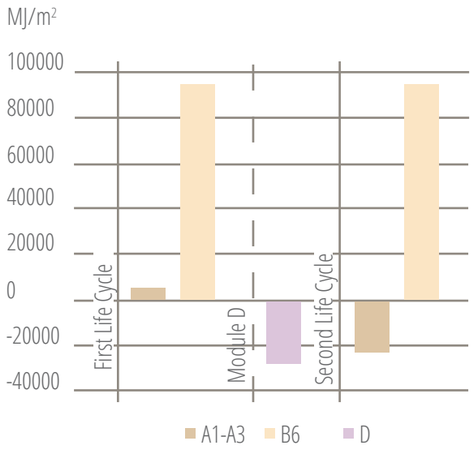
	GWP	ODP	POCP	AP	EP	PEnr	PEtot
Ouroboros	21,44	33,06	32,93	28,07	32,65	32,3	37,39
DGNB reference	100	100	100	100	100	100	100

As a tool in the early concept phase, the comparison between the environmental impact of the building and the DGNB reference assisted the team in creating a building envelope of low environmental impact. Later, by inputing the low operational energy demand, that was resulted from the implementation of passive and active strategies, to the LCA model of Ouroboros, and after replacing straw bale to cellulose insulation and reducing the use of plywood, it was established that the building gets the score of 100 pts, according to DGNB ENV 1.1 - Life Cycle Impact Assessment, proving that it is a building with a significantly low environmental impact.

The full report of the assessment of the building is handed as a separate document.

LCA indicators	Ouroboros	DGNB points	Weighting factors	Points*WF
GWP	21,44	100	40%	40
ODP	33,06	100	15%	15
POCP	32,93	100	15%	15
AP	28,07	100	15%	15
EP	32,65	100	15%	15
			Total (pts)	100

APPENDIX 9: LIFE CYCLE ASSESSMENT OF PV PANELS



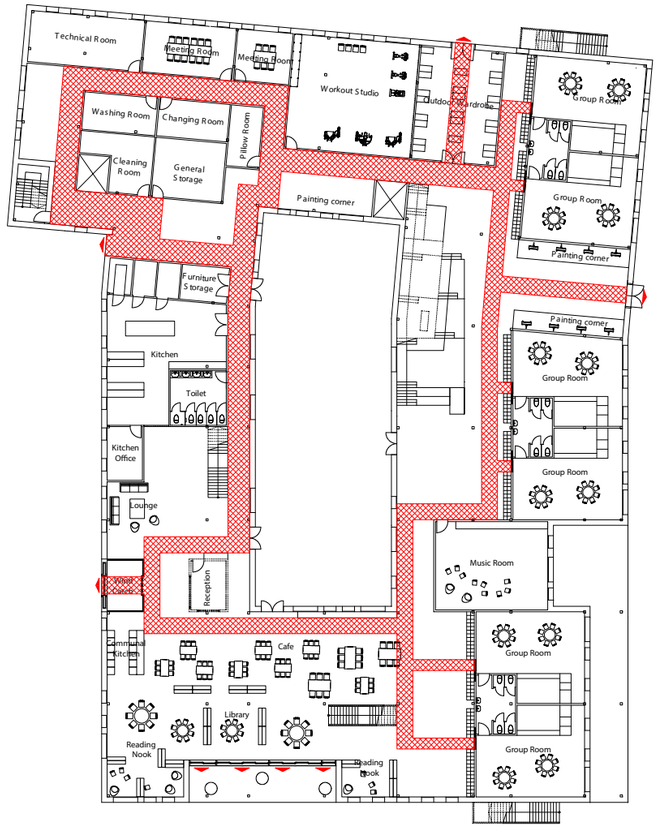
	A1-A3	B6	C4	D
PERE (MJ)	993,5	95000	20,26	-10900
PENRE (MJ)	3913	0	73,02	-16600
NRSF (MJ)	0	0	0	0
RSF (MJ)	0	0	0	0
Total (MJ)	4906,5	95040	93,28	-27500

	A1-A3 (MJ/m²)
1st life cycle	4906,5
2nd life cycle	-22593,5

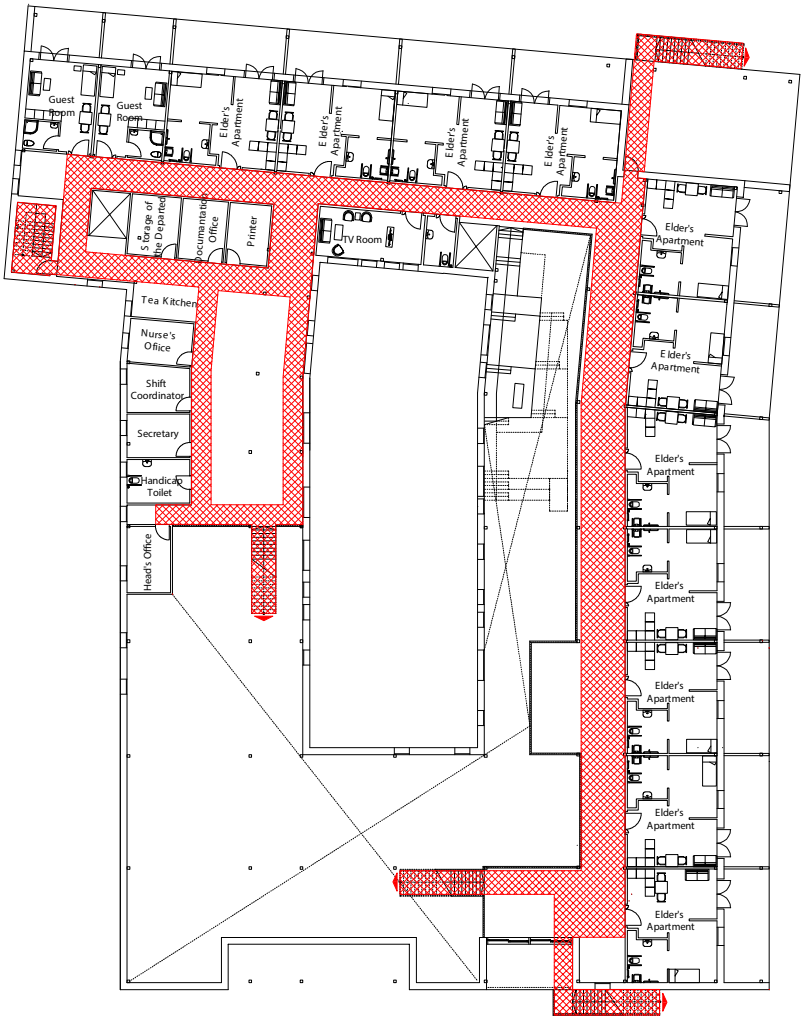
The present life cycle assessment concerns 1 m² of a photovoltaic system of 1200 kWh/m²*a and includes the PV module, cables, fasteners and inverters. The sample was considered to have a lifetime of 20 years and the loads and benefits from disassembling it and reuseing or recycling its materials is included in its EPD, which is available online at Oekobaudat.de. The calculation of the loads and benefits happened based on the fact that PV panels can be disassembled, and considered that the included aluminum, steel, and copper will be recycled, while the included plastic and printed circuit board will be thermally utilized to produce energy, and finally, that the glass and the PV cells will end to landfill. The material losses for the process of the materials is considered 5%.

The Product Stage A1-A3 represents the energy consumed for the raw materials to be extracted, transferred to manufacturing units and assembled to produce the PV panel. B6 represents the energy that the sample is able to produce in a life cycle of 20 years and Module D shows the benefits from disassembling and processing the product in order to stay in the market, insead of ending to landfill. Allocating the benefits from the first life cycle into the product stage of the second, shows that the PV panel should indeed be recycled, as this carries great benefits for the environment. Additionally, it can be argued that, since the expected degradation rate of the monocrystalline silicon PV panels is 0,5% per year, the component can remain in use until it no longer allows the building to be considered a Zero Enegy Building, and therefore, the life cycle of the PV panel can be prolonged, reducing the need for the manufacturing of new components and reducing waste.

APPENDIX 10: FIRE ESCAPE ROUTE



Ground floor fire escape route - 1:500



Upper floor fire escape route - 1:500