TITLE PAGE

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FIG.01 AAU logo

LIST OF CONTENT

MASTER THESIS

READING GUIDE

This master thesis researches the topic of how to build a sustainable co-housing where the report is divided into three major sections; Analysis, Research, sketching process, and presentation. The analysis chapter contains information of the chosen site, performed analyses such as the SAVE-method and genius loci. The research chapter includes evidential- and research based knowledge of the main subjects as environmental- and social sustainability, and energy renovation. The sketching process shows how the beginning ideas took shape into the final design that is presented in the presentation. To the master thesis there is an associated drawing folder with technical drawings in larger scale and an appendix with additional information.

FIG.02 The farmhouse on Faurskovvej 6 seen from the main road near Lilleåen

ACKNOWLEDGEMENT

Through this master thesis the group had a lot of external help and we would therefore like to show our gratitude to the people who helped us through this project, especially under the circumstances of a current world pandemic.

We would like to thank Anne and Lise from Andelssamfundet in Hjortshøj for giving us an insight into their daily lives in a co-housing community. They gave us a lot of information we could not have read in a book. We got an architectural guided tour in their community and helped us to hand out questionnaires to the rest of the residents.

Peter Jakobsen, co-owner of Ejsingholm ApS - Development and operation of properties gave us a guided tour at Studielandsbyen and answered questions concerning how the renovation process of a traditional farm building was handled, and we would thank him for sharing his knowledge with us. A thank you to the residents of Drivhuset in Randers who answered our questionnaire of how life within a co-housing community is for the individual. Favrskov municipality has helped us with accessing data of how many citizens were interested in living in a co-housing to determine our target group and they deserve a thank you for helping us. Lars Bjørk, formerly CEO of the architectural company Bjørk and Maigaard helped us with determining our concept and gave us tools on how we could move forward in our design process. We are very thankful and honored for his help.

Last but not least a big thank you to Kate and Jan Kjær who are the owners of the property we have been working with through our master thesis. They have been very helpful by sharing their stories and knowledge of the place and letting us visit the farm and site for research.

ABSTRACT

The researched topic of this master thesis is how to build a sustainable co-housing community in the country area through renovation of an existing farm building and further addition of new dwellings. The project addresses the increasing problem of empty farms that most of the time ends in demolition even though the building materials have not lived their full purpose. Furthermore, the possibilities of how to reuse local materials and build with biobased materials is also presented. This master thesis is carried out by Annika Maigaard and Anna Halstrøm Nielsen and concerns the design of a sustainable co-housing located in the country area near Hadsten. The design will include a renovation of an existing farm and addition of new building volumes. Through several analyses of the site and the existing farm, certain strategies, guidelines, and design criterias are made to have a more determined sketching phase. The end result was a common house in the existing farm and value of the traditional building technique by preserving the construction of the first- and second floor. New dwellings were designed as homes for the residents of the co-housing community. The project follows the integrated design process to have a final outcome with well integrated technical- and architectural aspects.

MOTIVATION

This is an inside of our motivation based on our experience, thoughts and interests

Through the years as students at Architecture and Design we both have experienced a deep interest in sustainability and the challenges the world is facing today and in the future. When deciding the topic for this thesis we discussed how to find a subject that investigated the challenges of sustainable living with focus on the material use and the social aspect of sustainability.

During fall 2020 we were at a conference called The future living where the project, Almanakken was presented. They addressed the challenges of urbanization and solved them by building new communities in the country areas but still with access to a larger city. Through some further investigation on the subject, we realized that in the last fifty years the population on earth has more than doubled in size, which also results in density increase and at the moment there are 7,8 billion people on our earth. (Worldometer, n.d.) In Denmark there are almost 5,8 million people, where 88,2% lives in urban areas. (Worldometer, n.d.) "...for the first time in our history, there are more people living in the cities and urban areas than outside the cities." (Dastbaz, 2016) Due to this urbanization a large part of Denmark is uninhabited because the Danish farming lands covers 61% of Denmark. The few agricultural farms in Denmark have more than halved with a decrease of 60% the last 30 years due to efficiency improvement of the fields. The minor farms become unnecessary and result in a large number of farms for sale. (Danmarks statistik, 2015) We strive to design redesign an old farm to give the opportunity for people to live in the country surrounded by nature and at the same time feel the possibilities and opportunities of the city are within reach.

We also want to address the ongoing issue of loneliness and how we, especially now with the world pandemic, can create an environment where people on a daily basic will be connected to a community (Chausa, 2018). By creating a cohousing where people will have their own homes with common shared facilities, they will have the opportunity to interact with other resident when they feel the need. The cohousing will be designed on an old farm where the existing farmhouse will be renovated and be a central part of the cohousing. Both the materials for the farmhouse and the new buildings will be selected based on minimizing the carbon emission. By doing this we hope to achieve an environmental and social sustainable cohousing.

INTRODUCTION

CHOICE OF LOCATION

For the choice of location some criterias were created to narrow the possible location. The project should be chosen somewhere in Jylland close to either Aalborg, Aarhus or Randers for easier access for the group. The preferable size was around 2 hectares for it to be large enough for a cohousing with several urban areas. Since we have focused on reused materials it was important for us to find a farm that most likely would be demolished when bought, to investigate an alternative solution and minimize the demolition process and further reuse the demolished materials. To find a farm like mentioned we searched for a low energy label and a long sales history. Because of the wish to design a co-housing it was important that there should be easy access to public transport and maximum an hour to a larger city. As shown in fig 03 old farms within 20km radius of Aalborg, Aarhus and Randers were investigated. After several possibilities we chose the farm on Faurskovvej 6 at the edge of a railway city called Hadsten.

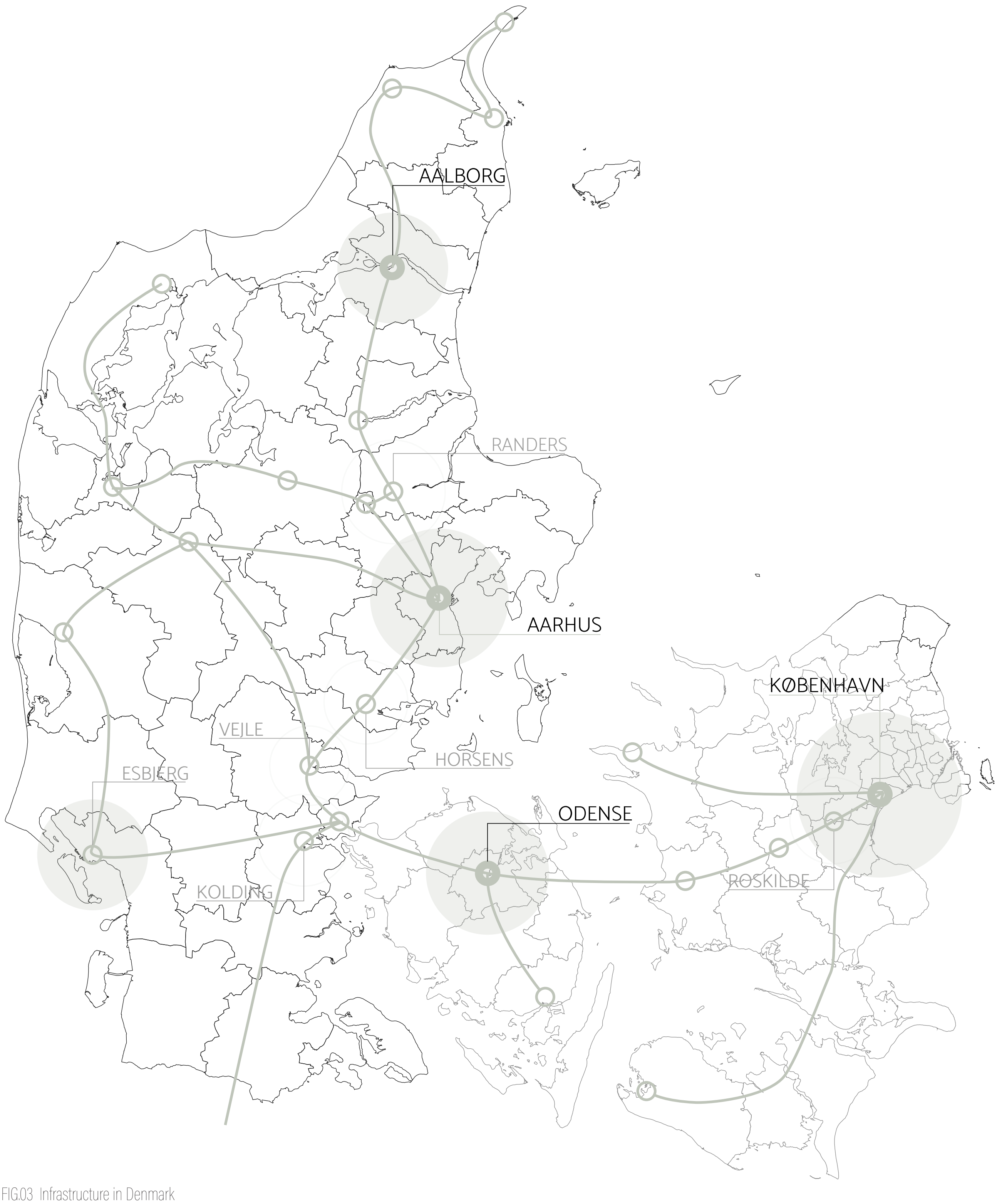


FIG.03 Infrastructure in Denmark

FAURSKOVVEJ 06

The existing building of 150m2 is a typical elderly farm building from 1922. As mentioned, it is located just at the edge of Hadsten and is 1.6 hectare large. There is a small garden to the building, a stable, a garage, carport and a shed.
The farmhouse is from 1922 and has been renovated and restored over time. In the 70's they pre-insulated the building by blowing insulation foam in between the exterior and interior brick wall. The wall had a width of 320 mm which is very thin and has a thermal transmission loss of 1.790 W/m2K.

There has been added some rooms to the main building, by pre-insulating parts of the stable and connecting them to the main building. The roof had been changed from the single tile roofing to tile boards. The demands for energy consumption of the building is fulfilled by an oil-fired boiler at the moment which is placed in the basement and is accessible through a trapdoor in the kitchen. There is a cavity under the building where pipes to the radiators are placed with a height around half a meter. The one string radiators are the heating source of the building. Electricity, water, and drain is received from the grid. The plan layout of the building consists of a 1st floor and a smaller 2nd floor. At the ground floor there are two living rooms and a suite in extension of the kitchen, two rooms, a bathroom and a scullery. The 2nd floor of the building has two bedrooms.

The bearing construction of the main building are the inner brick wall in the envelope and the inner middle wall. In the stable the inner brick wall and columns are the bearing construction.

FIG.04 The site 1:250

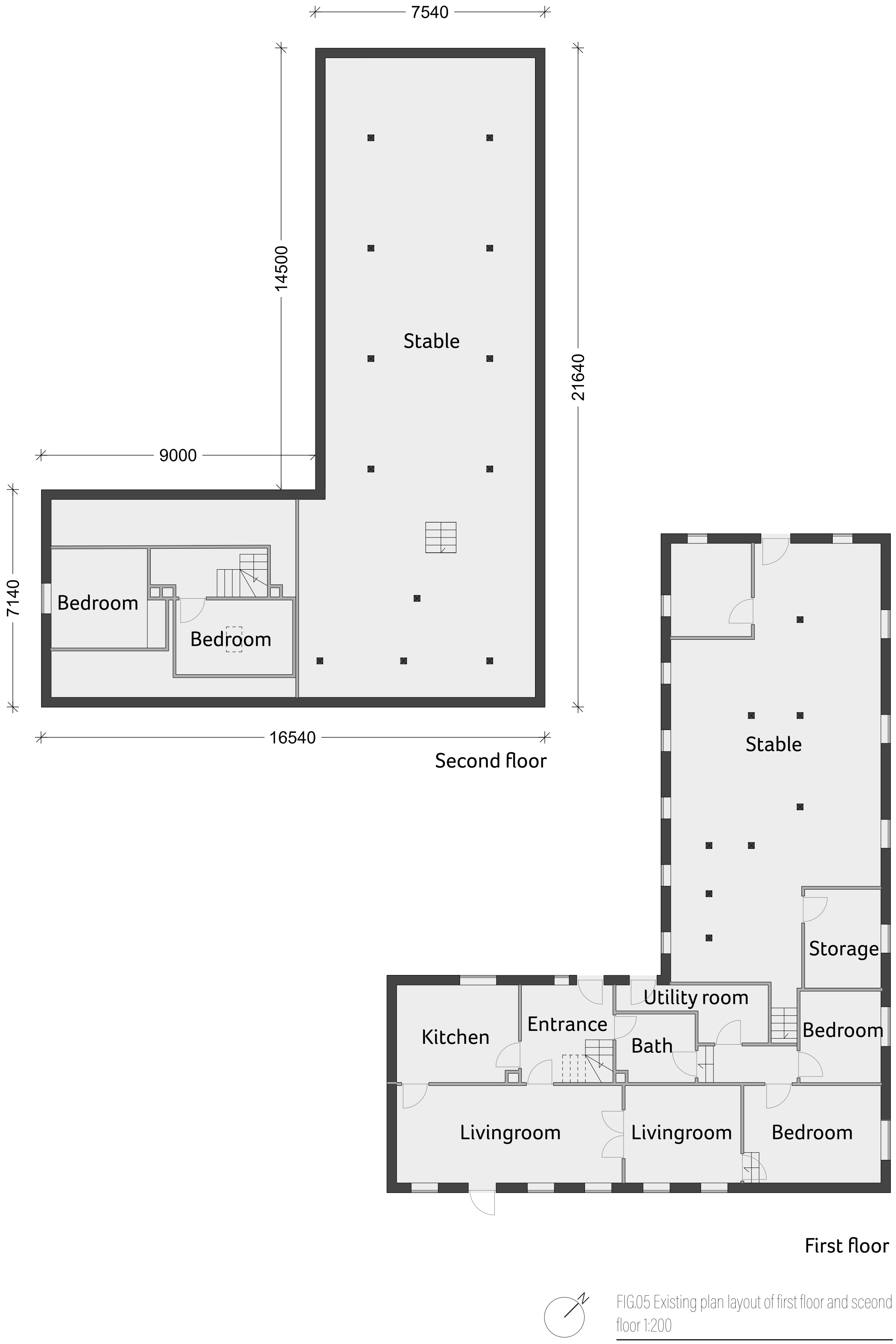


FIG.05 Existing plan layout of first floor and sceond floor 1:200

FIG.06 Facade of the stable

FIG.07 Patinated door

FIG.08 Valved ceiling in the stable

FIG.09 Gable of the main building

FIG.10 Stable window

FIG.11 Old photography of the farm

APPROACH

INTEGRATED DESIGN METHOD

To approach the project with an interdisciplinary between architecture and engineering and as a part of the education, architecture and design, it is embedded through the education to have a framework of the project within a holistic integrated design method. The integrated design method is developed by Mary-Ann Knudstrup and aims to integrate the architectural as well as the engineering aspects into a design proposal through five stages; Problem, analysis, sketching, synthesis, and presentation. The integrated design process is a method that helps to achieve a successful integration of the two professional skills, architecture and engineering. The method and the connections between the five stages is shown in fig.21 which is one of the most central elements because of the ability to move back and forth between the different stages. (Knudstrup M., 2004)

The problem phase is where the problem of the design project is defined in order to determine the main focus. In this project the focus subject is sustainable co-housing through social sustainability between its residents, and environmental sustainability through reused- demolished-, and biobased materials.
In the analysis phase the potential, opportunities or/and challenges are examined to create a foundation of knowledge to shape design criterias for the following sketching phase.

Serial vision by Gordon Cullen is a subjective method that visualizes a path from one end to another through drawings or photographs of different places on the route and results in a sequence of images. The drawings/photographs are subjective because of the individual investigator and can thereby vary depending on, who is using the method.(Cullen G., 1961) Through this project we use this method to visualize an understanding of the context through topography, volumes, dense, tall, or low vegetation through a human scale and perspective.

Genius Loci by Chrisian Norberg-Schulz means the spirit of the place in latin and was thought as a protecting spirit of a specific place in the roman empire (Oxford reference, n.d.). The method Genius Loci is determining the spirit of the place by using the senses of the body as a tool. This can be the five senses; smell, see, hear, touch, taste, or to observe recent activity, scale/structure such as sharp edges, large open lands, or the time of the place where historical/traditional shapes are investigated.(Norberg-S., C., 2000) This thesis uses this method by using the five senses to understand and determine the atmosphere of the place. The tools used in Genius loci is pictures, and subjective sense acknowledgement by the investigator.

Mappings by James Corner encompass an investigation of a place through maps with different characteristics in focus. This could focus on the infrastructure, public transportation grid, volumes, public functions or others of what the investigator finds interesting. (Corner, J., 1999) This thesis utilizes the mapping method to receive knowledge about the infrastructure, public transportation routes, and public functions to determine the accessibility to necessities, and the site. The tools used in this method are mappings through Qgis and diagrams to simplify the results.

State-of-the-art method takes offset in scientific articles that contents facts, studies, interviews, or experiments, also called evidence based- and research based knowledge. These scientific articles are a reliable source of information. The tools are web pages such as Google Scholar, AUB, libraries, and interviews and questionnaires.

Case studies is a method that investigates real life cases from specific focus points. Through this paper the case studies investigates the themes of renovation and building with biobased materials that can be used as inspiration later on.

Interviews and questionnaires are a method to gain qualitative and quantitative knowledge from people with relevance to a study. This paper contains qualitative semi-structured interviews of a few residents in co-housings and quantitative questionnaires for all residents in the investigated co-housings. During the interviews the group took notes and pictures and the questionnaire was made through an online webpage.

SAVE-Method stands for Survey of Architectural Values in the Environment. It is a method that maps out, register and validate conservation values of urban areas and buildings. For years the SAVE method has been an important part of the foundation of preservation of buildings in many municipalities. This paper uses the SAVE-Method as validation of the condition of the existing farm buildings. Tools such as pictures, and registration of the buildings.

The sketching phase is based on analogue and digital sketching, where the concept of the project starts by analogue sketches and later on in the process is being digitized due to a more detailed and complex level of design. The sketching phase has its roots in the design criterias that was defined in the analysis phase. Weighted scoring model is a method that is being used in this paper when design decisions have to be made on several criterias. The method is about giving the criterias a weight before scoring each design proposal, which aims for an objective decision. Furthermore, the method of working with focus on different categories such as functions, connections, urban areas, environment etc. will also be used. The tools through this phase are hand sketches, sections, 3D- and physical modelling.

The synthesis phase is where the ideas, sketches, and results from earlier phases is gathered into a cohesive design. This is where the final form is visible and the building can be tested on its performance to see if it lives up to the expectations. If the design does not live up to the wanted outcome the group will reflect upon what could have been a more suited solution. To achieve a good indoor environment the building volumes will be simulated through Bsim and other simulation tools such as Be18 that calculates the energy consumption in a year and, daylight visualizer calculates the amount of daylight on interior surfaces.

The presentation phase is where the material is gathered in a presentation of visualizations and diagrams that makes the design proposal understandable and appealing. The tools used in this phase is 3D modelling which includes spacial renders, detail drawings, sections, and plans. The diagram tool will also be utilized to illustrate some complex data in a simple and appealing way.

SAVE-METHOD

The interest in preservation of buildings and villages has largely increased in the last generations. This interest has blossomed due to constant change of the cities and landscape during the postwar. After WWII there was a large number of building demolitions of historic buildings and cheap housing/ apartments were built because the economy was tight. The cities were being optimized and made more effective to the consumer society that we know today. A large number of farming houses was and still is seen as unnecessary because people moved to the city and the infrastructure developed around the concept of urbanization. In the 1960's and 1970's many preservation associations were founded trying to preserve the culture and history of architecture. In 1975 they made it possible to get a grant for renovation as an alternative to demolition. They did this to make it more desirable to preserve the original architecture and thereby the culture.

PRE-WORK

The SAVE-Method stands for Survey of Architectural Values in the Environment. It is a method that maps out, register and validate conservation values of urban areas and buildings. For years the SAVE method has been an important part of the foundation of preservation of buildings in many municipalities.

The method consists of three phases; prework, field work, and Atlas. Prework is where the surrounding buildings, the local building techniques, the history, and topographical observations are made to determine the context and what to compare with. This results in a mapping of the builded structures where architectural, topographical, and historical observations are very important. The SAVE-Method draws parallels to Vitruvius' Virtues by using the holistic approach by joining a coherence between three subjects. The SAVE-Method strives to merge the architectural, topographical, and historical knowledge and thereby validate the preservation value.

FIELD WORK

The overall of the building is valued on five different stages; architectural value, cultural and historical value, environmental value, originality, and condition. This is done through a text based on pictures of the building details. Examinations such as signs of decline, earlier bad renovations, change in architecture, ornaments, and detailing.

SUGGESTIONS & CONCLUSION

The final phase consists of a conclusion of the landscape, historical, architectural values that should be preserved and suggestions to follow where the architectural and spatial observation are the main concern. It should be validated if certain initiatives would weaken the architectural language and qualities. The suggestions should be based on the topographical, historical, and architectural investigations. The suggestions mainly concern renovations, change in building functions, future building extension and their architectural expression, or identifying a cultural environment.

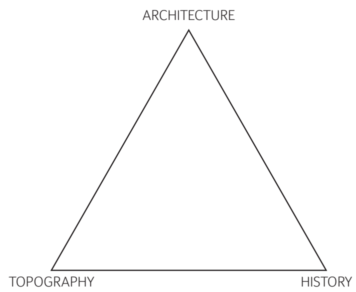


FIG.12 The trinity of the SAVE-Method

CHAPTER CONTENT

The chapter of theory contains theoretical knowledge of subjects in interest such as what is the current world situation concerning climate change and the importance of building sustainable solutions. This thesis take on sustainability is explained through renovation strategies of an existing building, why to renovate and the importance of minimizing the energy consumption through renovation. Using biobased materials and demolished materials is another take on how to build sustainable where theoretical terms and facts of the mentioned subject will be explained. The definition and values of a co-housing will be investigated through research based knowledge as well.

THEORY

FIG.13 Stacked used bricks placed near the farm

INTRODUCTION

For some time sustainability has been widely discussed and especially in the field of the building industry. The building regulations continually increases the demands for energy consumption trying to lower the emission and its causes. Even with new technology the building industry is still an increasing cause of global emission. Almost 40% of the global emission comes from the building industry. (European parliament, 2010) Operational carbon is the cause of 28% and embodied carbon is the remaining 11%. (Architecture2030, n.d.) Embodied carbon is a term used to describe the emission caused by the whole process of getting the raw materials, transportation, construction, maintenance, and the building's end of life phase. LCAByg can be used as a strategy to analyze these phases to address the choice of material, which will be carried out in this paper. Operational carbon is the emission caused by the energy consumption to operate the building. New buildings have a low energy consumption due to the building regulations but many existing buildings don't fulfill the current regulations. Therefore, it is necessary to renovate the existing buildings so the operational carbon emission can be reduced. It is also necessary to select the materials according to minimize the embodied carbon.

When talking about sustainability it is often associated with the environment but it is not the only form of sustainability. Sustainability can be divided into three categories; environmental-, economic- and social-sustainability. (Brundtland, 1987) Through this project the main focus is on environmental- and social sustainability. When social sustainability is a focus area it is important to research existing social issues. As previously mentioned in the motivation chapter, loneliness is a very common issue in the world today (Chausa, 2018) and especially in these times with a world pandemic. Therefore, this master thesis focuses on bringing people together in a co-housing community. Co-housing is also a possible solution to urbanization because of its location on an old farm in the country area surrounded by nature. Hereby, people have a choice of living in nature but with the opportunities and benefits of a closeby larger city with transportation, shopping possibilities and other facilities.

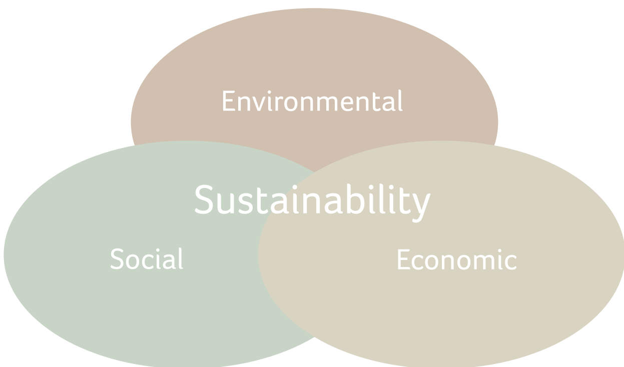


FIG.14 The three categories of sustainability

ENERGY RENOVATION

Why renovate?

The lack of regulations in previous years' buildings industry have a substantial negative impact on the global emission today. There is now a need to renovate existing buildings to minimize the energy consumption and thereby the operational carbon emission. At the moment renovations only affect 0,5-1% of the building stock annually which is minimal when knowing 28% of the world emission is caused by operational carbon. (Architecture2030, n.d.) A social sustainable reason why existing buildings should be renovated are to improve the indoor environment and thereby improve the quality of life. The indoor climate has a large effect on people's health (Kolarik, J., n.d.) and when people use 90% of their lives indoors (Yiannoulopoulou, L., 2017) it is important to fulfill the demands of atmospheric, thermal, visual and acoustic comfort.

What is energy renovation?

Energy renovation is to improve the energy performance of a building by renovating it. By improving the envelope of the building the thermal loss can be reduced and thereby less energy is needed to control the thermal conditions in the building. The current form of energy supply to the building will be investigated and replaced if needed to accommodate the energy demand and minimize the use of non renewable sources. Technical installations such as mechanical ventilation should also be improved with heat recovery. (Björn, Astmarsssson, 2013) There are some characteristics that distinguish the process between renovating and building new. First, there is an existing building which has a certain building style and architectural expression. This quality needs to be taken in consideration through the design process and categorized as worthy of preserving if it is the case. Renovation is about evaluating the state of the existing buildings and evaluating the needs of replacement or repairing. (Jensen, P. A. et al., 2018)

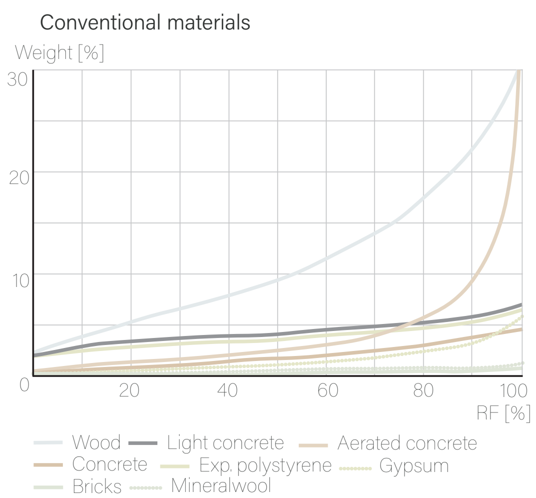
Conclusion

When energy renovating the goal is to improve the existing buildings energy performance. This can be done by improving the envelope so there is less heat loss and by changing technical installations and energy supply with focus on renewable sources.

BIOBASED MATERIALS

Due to climate changes, rising sea levels, and increasing amounts of CO2 emitted every year it is vital to investigate the choice of sustainable building materials in a project. This chapter contents examples of bio-based materials and their associated advantages compared with conventional building materials. Bio-based materials originate from living organisms which means they contain carbon that helps them decay in nature, also named as biodegradable materials. Examples of bio-based materials are reeds, clay, wood, eelgrass, rammed earth, and mussels. The materials can be used in their original form or be processed to increase the abilities of the material. Some examples of processed bio-based materials are for instance hempcrete, ecococon straw panels, or burned wooden facade. Bio-based materials have good thermal and acoustic properties, they are highly hygroscopic, often have a low density, and large- or multi-scale porosity. The thermal properties depend on the density of the materials, where materials with a high density have a higher thermal conductivity and are therefore able to store heat and contribute with passive heating. Bio-based materials are good at water vapor sorption and this ability can help with the indoor climate concerning humidity and be a natural regulator of the relative humidity. (Frandsen, K., 2020) Bio-based materials can to an extent be defined as breathable materials through their moisture storage properties. This is shown in fig.15.

With the material advantages concerning their natural properties bio-based materials also have advantages concerning carbon emission during the production. The pyramid shown in appendix 1 compares the kg CO2/m2 of conventional- and bio-based building materials through the production phase. In this figure it is important to remember the quantity of the material and lifespan can change the placement in the pyramid. (Frandsen, K., 2020)



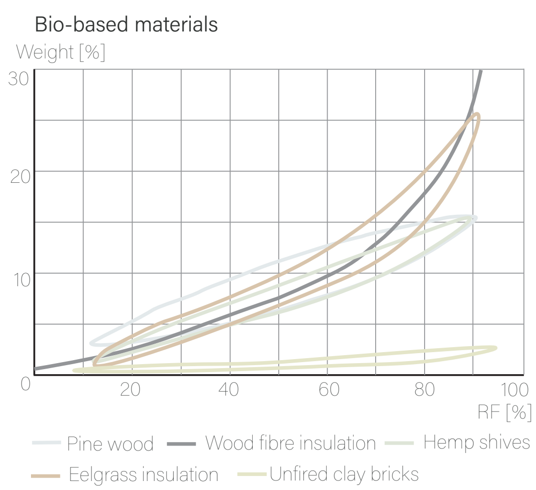


FIG.15 water vapor sorption (Svennberg, 2006)

DEMOLISHED MATERIALS

Reuse is defined as an object that is used through its original purpose, and recycle is an object that has been given another purpose than originally. The common types of building material waste is wood, concrete, ceramics, metal, and paper products. There is not calculated a percentage of the different waste products but the quantity of waste materials during a demolition of an ordinary residential house is estimated to be 1.3-1.6 ton/m2 of the ground floor area. For industrial structures the value is 1.5-2.0 ton/m2. (ScienceDirect, 2007) 30% of all waste in Denmark is building waste and even though we currently recycle 80% of the total building waste in Denmark there is still a larger potential of those materials (InnoBYG, 2016). The amount of reuse is very limited and materials that are considered as reusable are mainly bricks and tiles. This indicates that there is a need to establish knowledge of materials that can be reused to secure the embedded value of the materials and lower the needs for reprocessing. (InnoBYG, 2016) InnoBYG has published "Materialeatlas" which is a reference work where building parts and materials are investigated concerning toxic gasses. This approach to reuse and recycle of building waste is also addressed in "Delivering the circular economy - A toolkit for policy makers" by Ellen McArthur. McArthur mentions the term "circular economy" that addresses the end of life phase where instead of demolished buildings and increased landfills areas, the materials should as much as possible be reused or recycled, see fig.16. She addresses the need to move from a linear- to a circular economy. (Ellen McArthur foundation, 2015) With a closer collaboration with demolition companies during the design phase and when choosing new building materials could be possible solutions, according to Anders Lendager in "A changemaker's guide to the future". (Lendager, A.; Vind, L. D., 2018) LCA will be used in the design process to evaluate different materials.

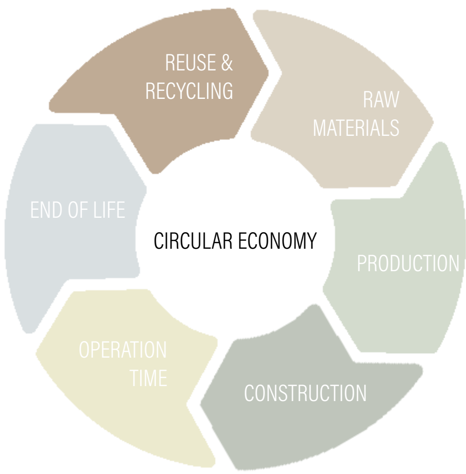


FIG.16 Circular economy

CO-HOUSING

Why make a co-housing?

As previously mentioned loneliness is a common problem and has a negative effect on people's health and everyday life. Loneliness is being compared side by side with smoking and obesity when examining the risk factor for illness. (Chausa, 2018) By creating a co-housing that offers the possibility of interacting with others and creating new relations through daily chores could be a possible solution to this increasing problem. Even though the compact living situation and high population in the cities the problem of loneliness is increasing which is due to a lack of interaction between the residents. A co-housing community can be an alternative to this compact and introverted lifestyle by sharing facilities as laundry, aplienses, guest rooms, toilets etc. This will also reduce the quantity of facilities that consume energy and thereby minimize the amount of carbon emission.

What is a co-housing based on field studies?

The group conducted interviews and sent out questionnaires to receive relevant evidence based knowledge of what a small community looks and feels like. The interviews and questionnaires can be seen in appendix 2. A field trip was made to both Andelssamfundet in Hjortshøj and Studielandsbyen in Viby. Questionnaires were sent out to these two communities and Drivhuset in Randers as well. The questionnaires have been answered by some of the residents in Andelssamfundet and Drivhuset.

Andelssamfundet's way of living together is with the focus on a common vision on living sustainably. There is a great diversity in the community and there are different housing types and economies to accommodate the different people. Every resident has their own homes but share some of the facilities like laundry and common houses. They focus on creating volunteer groups that are based on the residents interests and hobbies as a way of connecting the residents and the local community.

In Drivhuset they focus on the connection with nature and each other. They are placed at the edge of the city with a view over the fjord. Five times a week they all have dinner together which is valued very high for the residents, both because they create relations between each other and because they save some time and money by not having to do it themself. They also have working groups to take care of the gardens, common kitchen and maintenance of the building.

Studielandsbyen is a small community for students. They have a common house but it is rarely used. They use it to have dinner together once a month, but because of its large open space the residents don't use it when they only are a few people gathering.

FIG.17 Andelssamfundet in Hjortshøj

What is a co-housing, based on research?

It is complex to define what co-housing is because it changes according to time, place, residents and the culture it is made in. The article What is Co-housing? by Anna Falkenstjerne Beck gathers different studies of co-housing, and defines a conceptual framework of co-housing to get a better understanding of the phenomenon. The article is based on both interviews and literature researching historical ideas and different case studies. (Beck, Anna Falkenstjerne, 1999) Co-housing can be defined as a group of houses where people have their own private homes and share common facilities. Co-housing is not only physical, the residents also share common values and norms which contribute to their lifestyle. All the residents make common decisions together and interact socially with each other. It is important for the resident to both have a feeling of togetherness and individuality. A way to create interaction between the residents is by having common dining, working groups, celebrations etc. The article addresses the importance of making it possible for the residents to meet informally and spontaneously by having the common house as a central part of the co-housing having it located so that people often walk by and naturally arrives to. (Beck, Anna Falkenstjerne, 1999)

Conclusion

Co-housing a about creating a small community where different types of people live and have their own home but share facilities and a vision on how they live together and connect to each other. The residents can create relations between each other by having work groups and common facilities, in different sizes/dimensions, like outdoor spaces and a common house where they can have common dining, meetings and events.

CHAPTER CONTENT

This chapter contents the beforehand analysis, the site analysis, and field work. Later on there has been made research on topics such as LCA of the local materials, references of other existing co-housing such as Andelssamfundet, Studielandsbyen, and Drivhuset. The knowledge from research based knowledge and the visited co-housings will help to determine the residents for this master thesis.

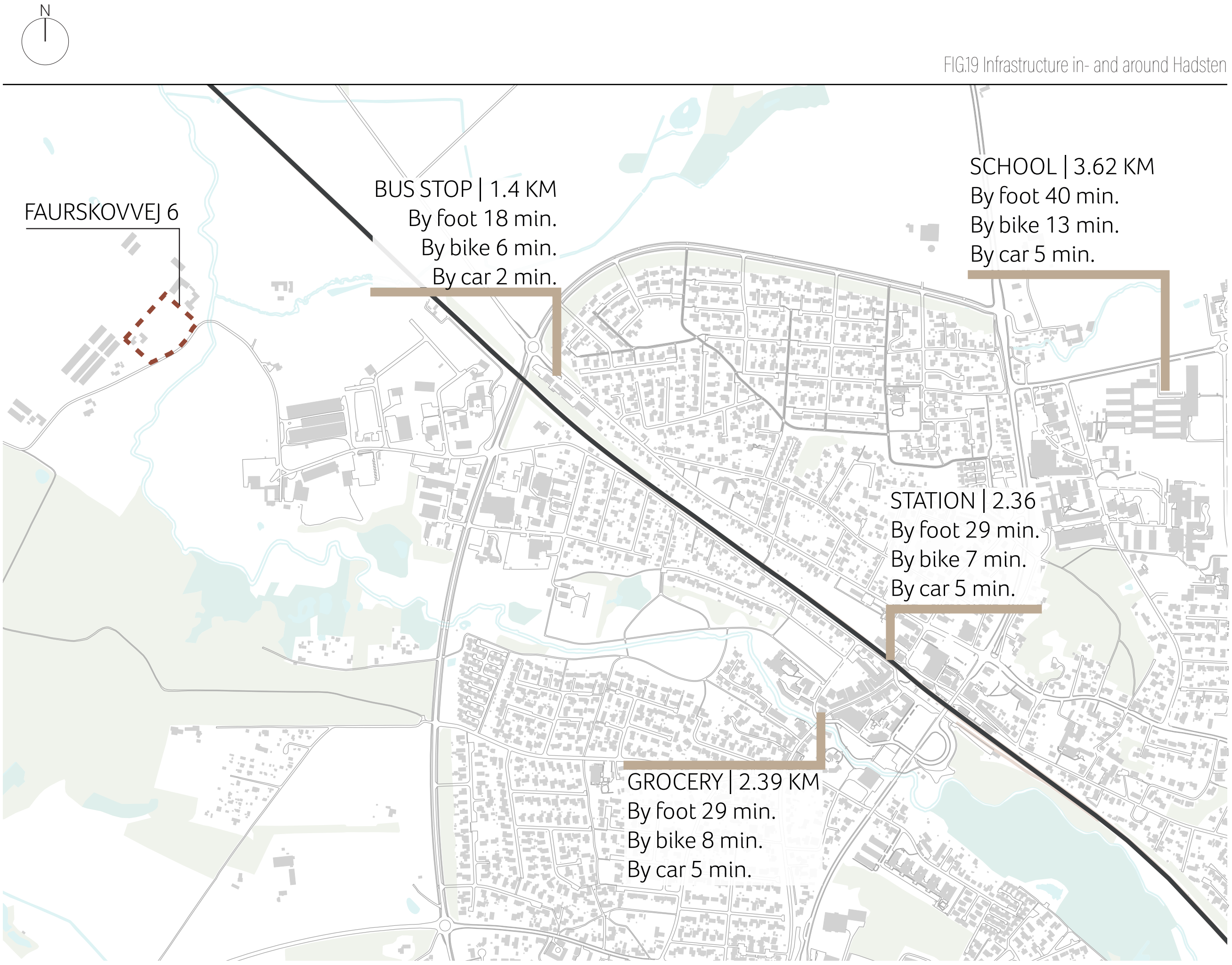
ANALYSIS

FIG.18 The farmhouse on Faurskovvej 6

INFRASTRUCTURE

The infrastructure has been examined, to gain information of how easily accessible the project site is and accessibility to public functions.
Even though the site is located just outside Hadsten the nearest bus stop is 1,4km away. This will create problems for people with minimal mobility. Therefore, to achieve a mixed target group there is a need for an alternative transportation solution to make it convenient for seniors or families with small kids to arrive at Faurskovvej 6. This will be solved by having shared cars and electrical bicycles in the co-housing community.

FIG.19 Infrastructure in- and around Hadsten



GENIUS LOCI

FIG.20 Lilleåen

THE LANDSCAPE

The harsh wind in January bites the cheeks when walking in the open landscape. The calm silence of the landscape makes it feel like we are all alone in many miles. The shy voices of nature take shapes in rustling dead leaves on the cold field, the sound of howling wind in the ears and the crumbly sound of the frozen grass from every step. Infrequently a bypassing train or cars and close by farm animals gives away the presence of other living nearby. The nearby farms bring bypassing smells of hay and animals to the refreshing wind.

The landscape is curvy and travels down to a stream just at the end of the farm's field. Along the stream nature thrive and some of the branches of the larger trees stretches into the water. The trees create a shielded and calm environment. The edge of the stream reveals that it frequently goes beyond its widths. The calm atmosphere by the stream brings peace to mind and seems far away from the city even though it barely passes the city sign of Hadsten.

CO-HOUSING IN THE NATURE

The qualities different qualities of nature can be used in the design of the outdoor area of the co-housing. Some areas will be exposed to weather and be open with a view to the landscape just like the atmosphere by the fields. Other areas will be more shielded from weather and enclosed as it is by the stream. This gives opportunities for the outdoor spaces to encourage to different encounters between the residents.

FIG.21 The movements of Lilleåen

FIG.22 View from the farm over the bare fileds

FIG.23 View from the farm at Sølund forest

FIG.24 The fine grass on the fields

FIG.25 A pine tree placed near the farmhouse

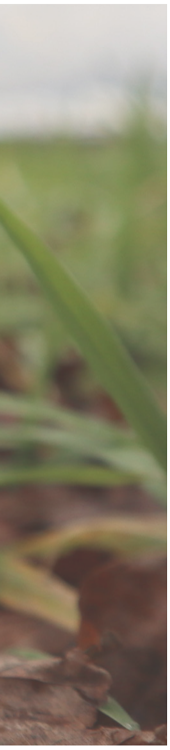


FIG.26 The organic shape of Lilleåan

SERIAL VISION

FIG.27 Map of serial vision routes

FROM THE CITY

The station of Hadsten is the start location of this route. The buildings are not more than 3 stories in height and almost all buildings are covered in red bricks that creates a union and coherence through the city. Moving further along the road, the railway parallel follows the road. On the left there are family houses in many different architecture styles done by great craftsmanship with a good sense for details. The uneven distribution of volumes along the road creates a feeling isymmetry. The industrial area is located further down the road and where the buildings are lower and more spreaded out and is located right before the city sign of Hadsten.

FROM THE NATURE

The start location for this route is located in a horse stud area with large fields and riding fields. The fields creates long views and is only interrupted by the small hills or the trees that defines the direction of the asphalt road. When moving closer to the site, the number of farms decreases and the forest takes over. The road defines the border of the forest and the road is narrow with sharp turns which demands one to drive slowly. The scenery of the road gently varies with dense forests and farm houses in small clusters of 2-3 homes.

CONCLUSION

From this analysis we can conclude that the project site is located at the border of change in topography, volume size and amount. We aim to design a new housing cluster and mimic the volume language in shape of the saddle roofing and sizes. Furthermore, the contrast of dense vegetation and large bare fields will as well inspire the design proposal.

FROM THE CITY

1

2

3

4

5

FROM THE NATURE

1

2

3

4

5

FIG.28 Pictures from the serial vision routes

SAVE-METHOD

PRE-WORK

The SAVE-Method has been a large part of the analyzing phase because the method can help to determine what existing building parts are worth preserving and what is not, based on architectural, topographical, and historical observations. The method have been used on the existing building volumes on the project site. For further detail of the analysis see appendix 3.

FIG.29 Stable window

WHAT TO PRESERVE

Through this analysis the group aims to preserve the half bowed window openings, the multiple mullions frames of steel, the valved ceiling in the stable, and the Y-shaped timber construction because of their local architectural history. The saddle roof will be preserved to be true to its shape and still fit into the street image. All the mentioned elements are valued as high architectural and historical elements of the farm and will be a part of the new building extensions to manifest the spirit of the site.

WINDOWS | CEILING | COLUMNS | ROOF SHAPE | DETAILS

WHAT TO DEMOLISH

The wooden sheds will be demolished due to multiple molded wooden planks. The roof of the building is badly insulated and has been weathered a lot over the years. Furthermore, the ceramic tiles contain asbestos and the group has therefore decided to demolish the roof and avoid reusing the tiles elsewhere in the project because of toxic gasses from the asbestos. The terrace plateau made of aerated concrete, the skylight window, and the chimney of red bricks that is out of use will be demolished. The gable of the stable facing North/West will most likely also be demolished because of large construction damage which the group estimates as an expensive restoration. There are cracks through the whole construction and a large gap between the gable and ceiling on the inside. The oil fired boiler in the basement will be removed and a renewable energy source for heating will be integrated.

SHEDS | ROOF | CHIMNEY | PLATEAU | GABLE

WHAT TO RESTORE

The surface crack on the foundation of the building will be restored and it would be too expensive to build a new base. The cracked doors and broken windows will be restored to achieve low transmission loss and repainted. The surface cracks in the walls will be restored and pre insulated mainly on the external facade to live up to the current transmission loss values. The ceiling and construction in the stable will be restored while preserving as much as possible and the small round flower windows on the gables will also be restored to its original appearance. The group aims to renovate the foundation, external walls, and roof to fulfill renovation class 1.

DETAILS | WALLS | THE BASE | WINDOWS | DOORS

LOCAL MATERIALS

BIOBASED- AND DEMOLISHED MATERIALS

As Anders Lendager mentioned in "A changemakers guide to the future" it is important to design for a circular economy instead of a linear economy. At the moment the linear is more common, where the material has an end of life stage as demolished materials which also is called cradle to grave in life cycle assessment. When changing strategy to a circular economy the materials will be reused/recycled or even upcycled and be used in new building construction and is called cradle to cradle. As mentioned earlier it is important to design for a circular economy to keep the embodied carbon in the material and the numbers of landfills will decrease. Here, it is important to look for building materials at the companies who demolish buildings, because they are the one with the new building materials or as Lendager says "...*Design the world of tomorrow with the waste of today while at the same time designing a world without waste, demolition workers become a key collaborator for the architect/designer.*". (Lendager, A., 2018, pp.61)

When using biobased materials it is important that it is local materials to make it possible for nature to decompose the materials by itselves. If the materials are not local, then it would be less sustainable due to freight, life cycle assessment, and waste materials that can be composed in nature because of a different microclimate. The natural biobased materials we have determined are clayey soil and large nearby wetlands which results in materials such as reeds and clay. The reeds could be used as insulation in the construction, or thatched roofings. The clay could be used as exterior mortar, thermal mass on interior walls to stabilize indoor temperature, or sun dried clay bricks for building construction. Clay as a building material is very flexible and can have many different colors and textures.

Current demolition projects were found by contacting demolition companies and reading the local news in the area. A bridge in Hadsten has just been demolished which was constructed in reinforced concrete, the local fire station of red bricks, and by contacting demolition companies they informed that small farmhouses around Hadsten are being demolished at the moment. The reinforced concrete can be upcycled by crushing and mixed with new concrete and thereby minimize the use of new concrete. This could be used for foundations, walls, bearing construction and more. The reuse of the red bricks from the fire station are most likely made of lime mortar because it was constructed in 1949 which was before the use of concrete mortar. The red bricks from the fire station can be used as facade cladding, flooring or other. Furthermore, there are many stores that buy building materials from demolition companies close to Hadsten, that have a large variation of windows, doors, wood, bricks, and concrete.

FIG.30 Demolished materials sorted for reuse

FIG.31 Clay

FIG.32 Demolished bridge in Hadsten

FIG.33 Old wooden plancks

FIG.34 Reeds

FIG.35 Old fire station in Hadsten

ENERGY AND ENVIRONMENT

There are different regulations that need to be followed according to the type of building, if it is a new building or renovation and the chosen energy frame. The following numbers/requirements are from the danish building regulations and the danish building standards.

HEATING SUPPLY

The area around the farmhouse is not connected to the district heat for Hadsten. (KILDE) The existing heating system is an oil fired boiler. This will be replaced with a brain-to-water heating pump that will also supply heat to the new building. The soil on site is mainly clay and because of its high amount of water it has a high heat transfer to the pipes and are therefore optimal in this project. The brain-to-water heat pump is also a renewable heat source and is a sustainable choice.

INDOOR ENVIRONMENT

The indoor climate has a significant impact on people's health and wellbeing. In this project visual, thermal, atmospheric and acoustic comfort will be investigated. The scheme below shows the Danish standards of visual, thermal, atmospheric and acoustic comfort. These are to be achieved in this project.

Thermal comfort	Atmospheric comfort	Visual comfort
Max. 100 hours over 27 degrees Max. 25 hours over 28 degrees	Min air change rate 0,5 h^{-1} Exhaust air flow Kitchen: 20 l/s Bathroom: 15 l/s Toilet: 10 l/s	300 lux or more on at least half of the relevant floor area for at least half of the daylight hours Visual access to the surroundings
(Dansk Standard, 2019)	(Dansk Standard, 2019)	(Dansk Standard, 2018a)

FIG.36 Indoor climate requirements

The existing building will be renovated to meet the requirements for the energy frame renovation class 1. The building envelope to the main house will be renovated to meet the U-values for rebuilding. The stable will be renovated to become part of the common house and will therefore follow the u-values for changed use. (fig.37)

Renovationclass 1

Energyframe: 69,0 kWh/m^2 year

U-value for changed use

Building part	W/m^{2}K
External wall	0,15
Roof construction	0,12
Foundation	0,10

U-value for rebuilding

Building part	W/m^{2}K
External wall	0,18
Roof construction	0,12
Foundation	0,10

FIG.37 Renovation energy frame and U-values (Bygingsreglementet, n.d.2)

NEW BUILDING

The new buildings will mainly be residential living/homes. They will be built to meet the requirements for the energy frame low energy class 2020, to accommodate a more sustainable building. According to the regulations this energy frame has the same u-values as the general requirements for new buildings. (fig. 38) (Bygningsreglementet,n.d.2)

Lowenergyclass 2020

Energyframe: 27,0 kWh/m^2 year

U-value for lowenergyclass 2020

Building part	W/m^{2}K
External wall	0,30
Roof construction	0,20
Foundation	0,20

FIG.38 New building energyframe and U-values (Bygingsreglementet, n.d.2)

TARGET GROUP

The target group of the co-housing community is defined by knowledge of evidence-based interviews, research-based articles, questionnaires (appendix 2) and knowledge from Favrskov municipality concerning wishes from the citizens (appendix 4).

DWELLING SIZE

By aiming for a sustainable co-housing community there is aneed to reduce the energy consumption. By reducing the heated floor area and by sharing some facilities such as washing machines the less energy will be used. This project will focus on designing more compact homes with shared facilities to lower the energy consumption. The dwelling sizes in Denmark are rapidly increasing in size and the amount of sqm. pr. person as well. This project aims to design dwellings 40% smaller sqm. pr. person than the current average floor area pr. person in Denmark.

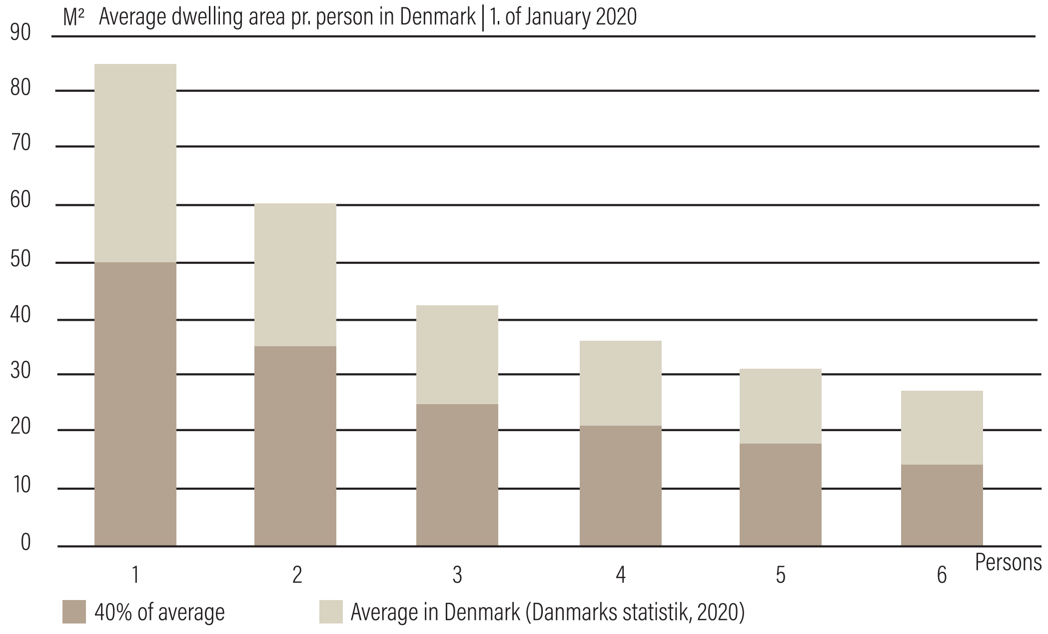
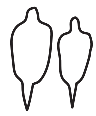


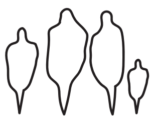
FIG.39 Area pr. person [m^2]

PERSONAS

A senior named Jacob currently lives in a larger farm house far away from the city. Jacob is living by himself and tends to feel lonely. Because of his age he has physical problems that gives him a hard time to maintain the farm. Normally, the family of Jacob would find an apartment or nursing home in the nearest city but will most likely result in feeling more lonely or misplaced. Jacob has a need for social relations with an atmosphere that makes interaction easy and natural. He wishes to have the same living conditions where he is close to nature has a house to maintain and but with easy access to public services.



Jane and Kasper have lived together for 25 years and the main part with their three kids. They live in a villa in the suburbs but now when all their kids have moved out they feel the home is too big for just the two of them. They suddenly have more time for themselves to find new hobbies and make new relations. Even though they want to live in a smaller place they still want to have the opportunity to have their kids and the whole family to visit.



Nanna and Kristoffer and their two young kids Alma and Mikkel are at the moment living in a villa in the suburbs of a larger city. The couple moved to the suburbs to live in a safe environment for the upbringing of their children and with easy accessibility to the necessities of the city. The couple never completely settled and they always felt a lack of communication with the local community. They likes the idea of living closer to nature but never had the time and resources to fully commit to the idea.

From all the collected knowledge there will be three different dwellings, which is listed below

	Number of people	Floor area	Numbers of unit
Housing unit A	1	50 M^2	5
Housing unit B	2	70 M^2	11
Housing unit C	3-4	75-85 M^2	3

FIG.40 Housing units

UNIT PROGRAM

Below, is presented a unit program for the common house and the three different dwellings.

72 people	Quantity	m^2	Qualities	Connected to
Common house 1. floor 208 m2				
Entrance	1	16	High ceiling Storage space	Common living room Toilets Laundry Storage space
Dining area	1	111	Valved Outdoor terrace	Kitchen
Common living room	1	38	Outdoor terrace Relaxing furnitures Entertainment	Entrance Greenhouse
Kitchen	1	17	View to court yard	Common dining area
Toilets	2	2		Sinks
Handicap toilet	1	3		Sinks
Sinks	1	6		Toilets Handicap toilet
Laundry	1	6	water outlet 4 washing machines (1 to 15 people) 2 dryers	Entrance Outdoor drying rack
Technical room	1	0,72		-
Storage	1	7		Entrance

Common house 2. floor 182 m2				
Guest rooms	2	10	visible construction east oriented windows	Hallway
Office space	1	53	diffused light visible construction Low noise nuisance	Hallway
Toilet	2	2		Hallway
Sinks	1	6		Toilets
Shower	1	8		Hallway
Storage	1	7		Creative room
Hallway	1	54		Creative room
Creative room	1	28	diffused light visible construction	Hallway
Children's room	1	22	visible construction	Hallway

	Quantity	m^2	Qualities

UNIT A 50 m2			
Entrance	1	3	Storage space
Kitchen	1	4	View to courtyard
Bedroom	1	13	Storage space
Living room	1	22	High ceiling height View to surrounding nature
Bathroom	1	7	High ceiling height View to surrounding nature

UNIT B 70 m2			
Entrance	1	3	storage space
Kitchen	1	5	View to courtyard
Bedroom	1	13	storage space
Living room	1	34	High ceiling height View to surrounding nature
Bathroom	1	6	High ceiling height View to surrounding nature
Room	1	10	High ceiling height View to surrounding nature

	Quantity	m^2	Qualities
UNIT C 80 m2			
Entrance	1	3	storage space
Kitchen	1	4	View to courtyard
Bedroom	1	13	storage space
Living room	1	38	High ceiling height View to surrounding nature
Bathroom	1	5	High ceiling height View to surrounding nature
Room	2	9	High ceiling height View to surrounding nature

PROBLEM STATEMENT

HOW CAN WE MANAGE THE CURRENT SOCIAL- AND ENVIRONMENTAL CHALLENGES THROUGH TRANSFORMATION OF AN OLD FARMHOUSE INTO A CO-HOUSING COMMUNITY THAT RESPECT THE LOCAL HISTORY AND GIVES THE CITIZENS AN OPPORTUNITY FOR AN ALTERNATIVE LIFESTYLE SURROUNDED BY NATURE?

VISION

The analyses and theory had led us to a vision that aims to design a community in the shape of a co-housing to create connections and relations between the residents but also to the surrounding local community. The farm co-housing will therefore have some public facilities such as events, social dining, and accessible outdoor areas but also common facilities for the residents such as activity groups, access to common house facilities, and events. This co-housing will have a focus on social interaction and assistance between the residents and thereby, be able to have a sustainable lifestyle by living in this co-housing community. The diversity of the residents will be important to gain different knowledge, initiatives and man power into the community. Animals and farming will be a part of the co-housing with focus on sustainability and the closeness to nature. The activity groups will most likely vary over time depending on the interest of the residents but their main purpose is to increase physical activity and interaction between the residents. We aim to renovate the existing building volumes on site to renovate class 1 and use demolished and biobased materials to decrease the carbon emission and energy consumption. The existing materials, architectural language, and details of the existing building volume will be integrated into the new building extension as much as possible to show respect to the local history.

We aim to design with passive strategies such as thermal mass, natural ventilation, and shading to minimize the energy consumption and integrate solutions such as heat pumps and rainwater collector to take advantage of renewable energy sources.

DESIGN PARAMETERS

1. The energy consumption of the existing farm should fulfill renovation class 1 and the new dwellings fulfil the low energy class 2020 and further be reduced by implementation of a brine to water heat pump supply.

2. The existing buildings and new dwellings will be designed and transformed with focus on passive strategies, as the building envelope, natural ventilation, orientation, thermal mass and bio-based surfaces to achieve a comfortable indoor climate.

3. The common house will be located in the existing farm with shared facilities and a common dining area for 72 people or smaller gatherings and promote relations between the residents.

4. The private housing units will vary in size to accommodate a mixed target group where the units will be designed with 40% less sqm. than the average dwelling in Denmark.

5. Outdoor activities such as; farming, animal care, outdoor exercise, playground, fruit orchard, plan boxes, fire place, wetlands, and pathways are distributed around the co-housing community to create interaction between the residents and nature.

6. The urban areas will change in vegetation and building density to create different atmospheres and experiences through; open areas with a view to the landscape, enclosed areas shielded from weather, with focus on biodiversity.

7. Strong, durable and low embodied carbon building materials with infrequent and basic maintenance will be prefered to reduce environmental impact and extension of building volumes lifetime.

8. Parking areas for shared-, private- and public vehicles will be implemented near the common house to act as a central meeting area of the co-housing community.

CHAPTER CONTENT

The following chapter shows the essential choices and sketching in the design process. As mentioned before the design process had many iterations back and forth and this chapter shows a refined process of an otherwise less structured design process.

SKETCHING

FIG.41 Rusten hinge

MASTERPLAN

The design process started with a physical model of the site to investigate the scale, form, and urban areas. The size and form of the new building volumes were decided in the analysis phase. The new building volumes would imitate the existing farmhouse through the shape of the saddle roof to have a connection between the existing and the new buildings. The existing farmhouse will be the common house and therefore the meeting point and heart of the co-housing. At first, we had four different sizes in housing units but after consideration only three housing units were further investigated. Different placement of the three housing units were. The beginning of the process can be seen in Appendix 5. The first concept was "the village" that was the concept of a small community where everybody would live close to each other (fig. 42). Here, building form 1. and 2. (fig.43) was used to create different urban spaces. After some consideration and further analyses of what the concept of this co-housing was and could contribute with, compared to a house in the suburbs, a new concept, "the farm" was initiate. (fig. 44) This concept focused on giving the resident a feeling of living on a farm surrounded by nature. The residents would still have possibilities of close interaction with each other, but live more spread out on the site than before. In this concept, a cluster consisted of four housing units that together would create a semi-public courtyard for the residents of the cluster.

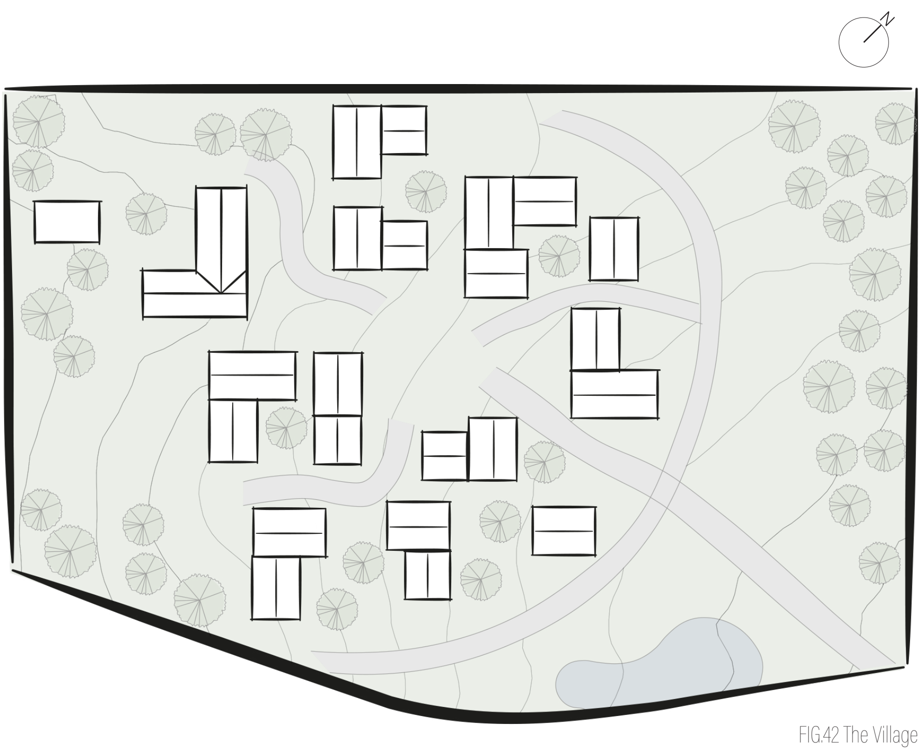


FIG.42 The Village

BUILDING FORMS

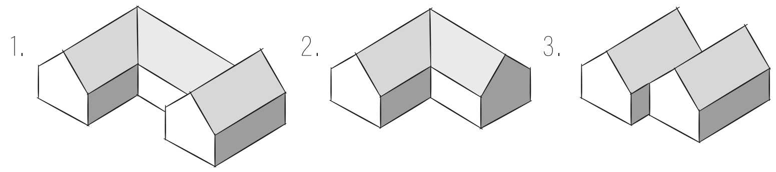


FIG.43 Building form

To receive a better understanding of how the design could be optimized concerning the energy consumption, the concept was modelled in Be18. At first the energy demand was at 43,4kWh/m2. If some buildings would be split in two to create a passage, the energy demand would be 48,3kWh/m2. Also, if all the building would be in two floors the energy demand would be 29,1kWh/m2. After consideration it were chosen to have half the building in two floors to have a small footprint and thereby less transmission loss. Furthermore, all the buildings would be connected in pairs to have less transmission loss through the envelope.

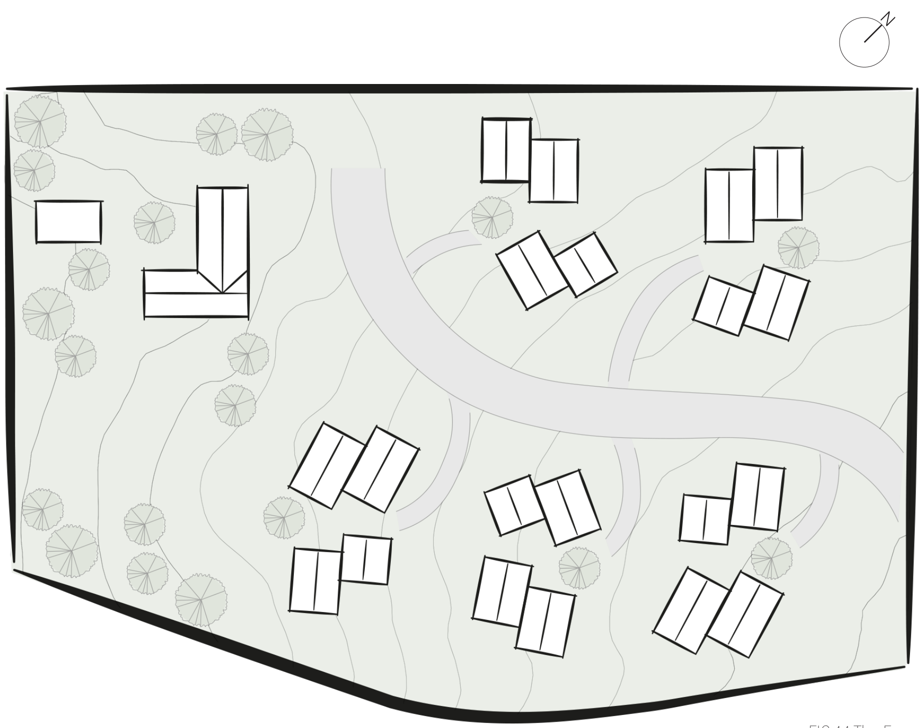
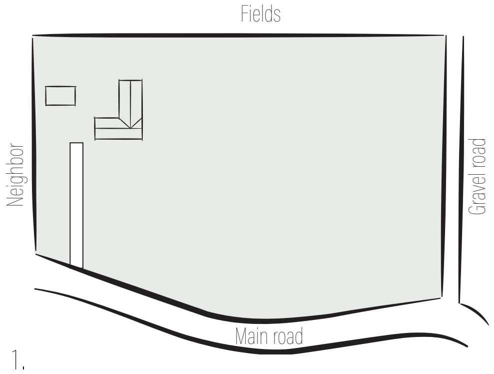


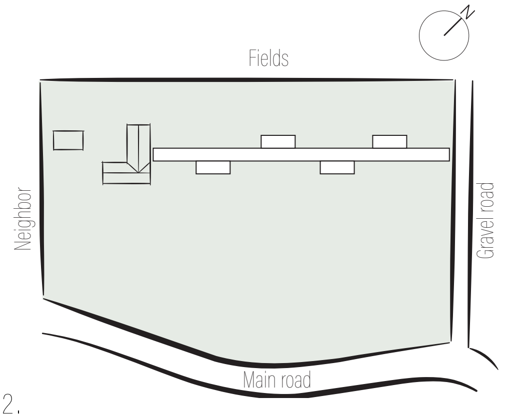
FIG.44 The Farm

INFRASTRUCTURE

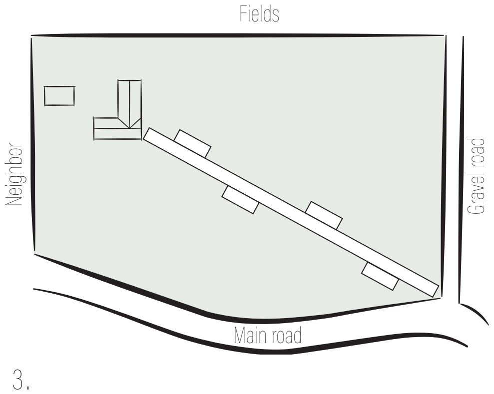
The existing road leading to the farmhouse is placed at the edge of the site as seen in illustation 1. Different suggestions were made on where the new main road would be placed knowing that the new dwellings would acquire parking spaces with easy accessibility.
With the road facing the common house, like seen in illustration 2 and 3, it framed the common house at the end of the road, but it also created an edge and divided the site in two. By having two small roads leading to the dwellings, the rest of the site becomes free of car traffic and the urban areas remains connected to each other, seen in illustration 4.



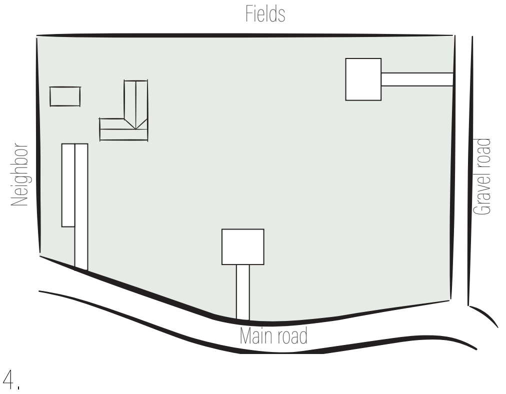
1.
The existing road leading to the farmhouse with direct access from the main road.



2.
The road placed towards the gravel road framing the farmhouse at arrival



3.
Creating a flow through the site by placing the road diagonally.



4.
Several access to the site by smaller roads leaving the rest of the site car free.

FIG.45 Infrastructure sketching

FUNCTIONS AND URBAN AREAS

To give the residents the feeling of living in a co-housing community the functions and urban areas play a vital role. As mentioned in previous analysis the co-housing will have animals and farming for the residents. This creates purpose for the residents by giving them everyday chores. These activities/functions connect the resident to the surrounding nature and to each other by having casual encounter in the everyday life. As seen in fig. 46 a green belt stretches from the corner of the site to the common house. This area will contain common functions such as animals, farming, and playgrounds. A pathway will travel through this green area and only be used by cyclists and pedestrians to have a safe space for activity. Smaller paths will create connections to the dwellings and activities along the main pathway. The residents will explore different urban experiences and atmospheres. Two roads will be placed near the dwellings with parking spaces. The existing road will remain and have parking spaces for visitors and hereby make the common house easily accessible.

The dwellings are oriented so most of them would get a view over the landscape and for those who do not would get a view towards the nature on site.

FIG.46 Recreative urban area

COMMON HOUSE

PLAN LAYOUT

The existing farmhouse will be renovated and transformed into the common house of the co-housing community. This will be where the resident can make casual conversation, alongside everyday chores. The stable will be transformed into the dining area with space for all the residents for common dinning. The rest of the first floor will have a kitchen, toilets, and living room. On the second floor there will be an office area to work from home, and other rooms for clubs or activity groups. Furthermore, there is two guest rooms for visiting family or friends. The two plans shown on page 59 are both first floor.

In the first proposal (fig. 47) the existing inner walls and stair are preserved to minimize the demolished materials. The inner walls and stair controlled the flow and divided the rooms into weird shapes which made it difficult for designing the plan.

The second proposal (fig.48) was made with a new position of the stair. This led to a more open plan layout where the common rooms were connected to each other. The kitchen was placed where it is today which are preferable for technical aspects, but it was no longer connected to the dining area. Next to the kitchen there would be access to a greenhouse that the kitchen could use to grow vegetables. The greenhouse would also become a place for the residents to sit in the colder months and enjoy the plants and the warmth of the sun.

The common house will keep the greenhouse at the gable, but the kitchen will be moved closer to the dining area, due to more frequent the flow from the dining area to the kitchen than from the kitchen to the greenhouse. There will also be implemented a laundry room to minimize the amount of appliances and creating a meeting point for the residents.

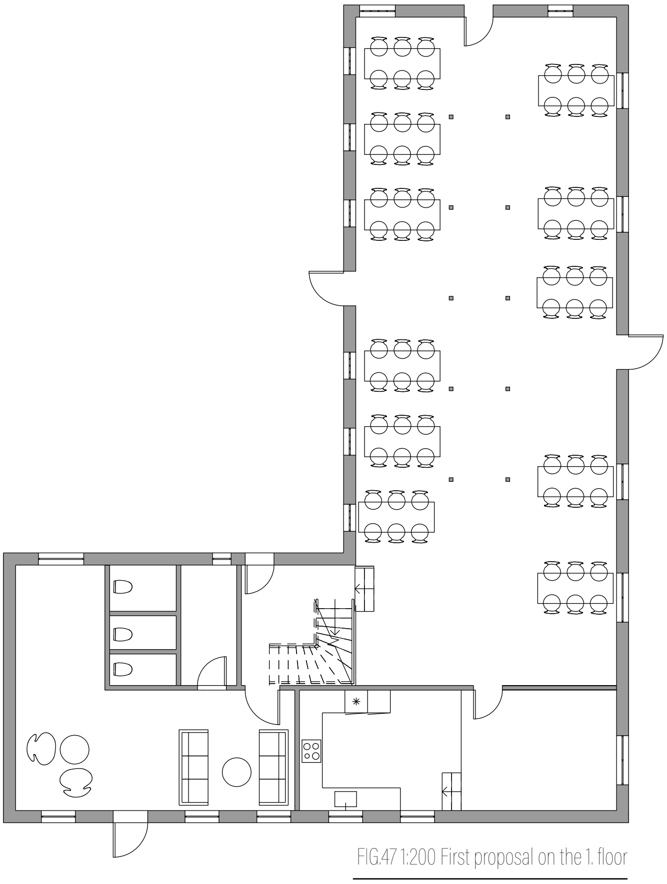


FIG.47 1:200 First proposal on the 1. floor

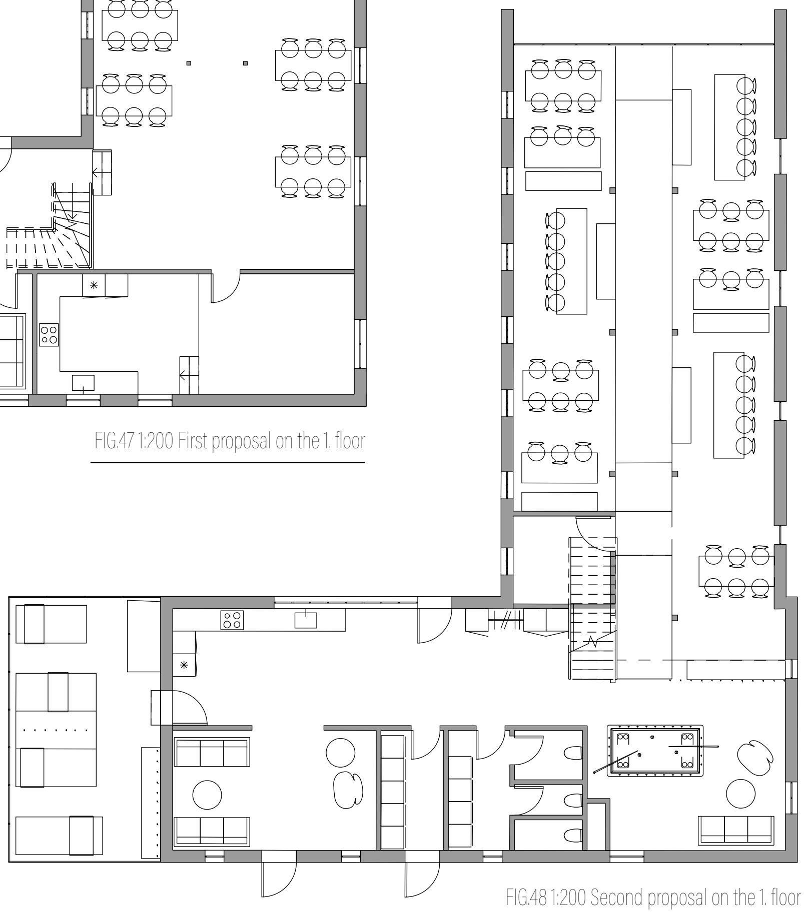


FIG.48 1:200 Second proposal on the 1. floor

RENOVATION

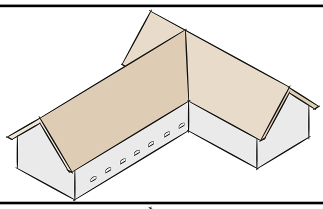
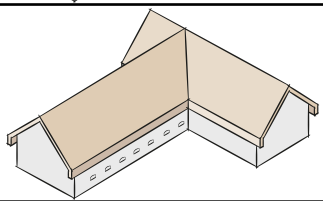
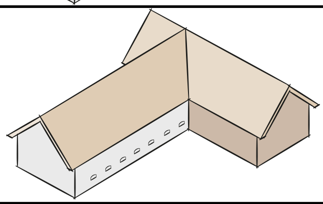
	Stable windows plane with the facade to emphasize stable expression	Common expression for the common house	Preserve visible roof construction on the 2.floor
Renovate on interior walls 	0	0	-
Renovate interior walls on 1. floor and exterior walls on 2. floor 	0	0	0
Renovate interior walls in stable and exterior wall in main house 	0	-	-

FIG.49 Evaluation scheme

The choice of how to renovate a building is very important for the expression and aesthetics. Through the SAVE-method it was a desire to preserve the architectural elements of the stable and its atmosphere as much as possible when transforming it into a common dining area. Three different proposals for transformation have been valued by comparing to the farm as it is today. The different renovation strategies were also compared on their life cycle assessment. (fig. 49) The second transformation proposal will be worked further with because it preserved the architectural elements that will maintain the history of the farm and according to LCA its better to renovate on the interior of the walls.

LCA COMPARSION OF EXTERIOR- AND INTERIOR RENOVATION

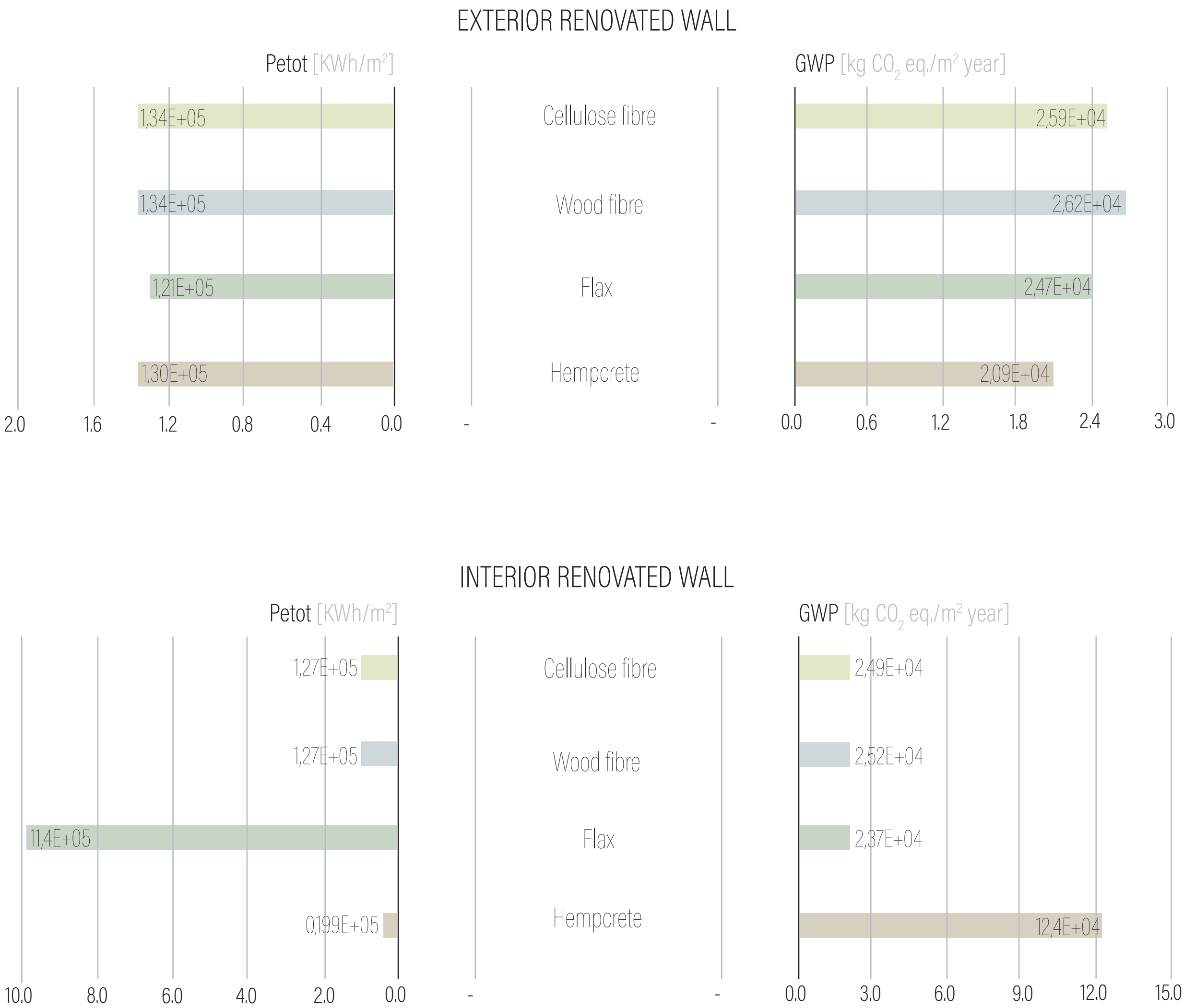


FIG.50 LCA results

DAYLIGHT

The sketching iteration on the common house has been highly influenced by the original window holes and bearing structure which gave some strict guidelines of the facade expression except for two gables of the building which was in very bad condition and ready to be demolished. This gave an opportunity to transform the appearance and design a coherence between the new dwellings and the common house. Since the common house is the main building in the co-housing community there was a wish to visualize an inviting building through transparency to open to its surrounding community and nature. Therefore, a large, glazed panels were integrated as gables to receive more light into the building and have a great view over the fields. Early on there was a need for a solid panel where the second floor meets the gable to hide the construction. Some glazed panels were exchanged with solid panels because there was a need for less daylight. This appearance was very dynamic compared to the clean shape of the new dwellings which then resulted in a thicker solid panel at the second floor connection and a shading overhang through extension of the roof and exterior walls.

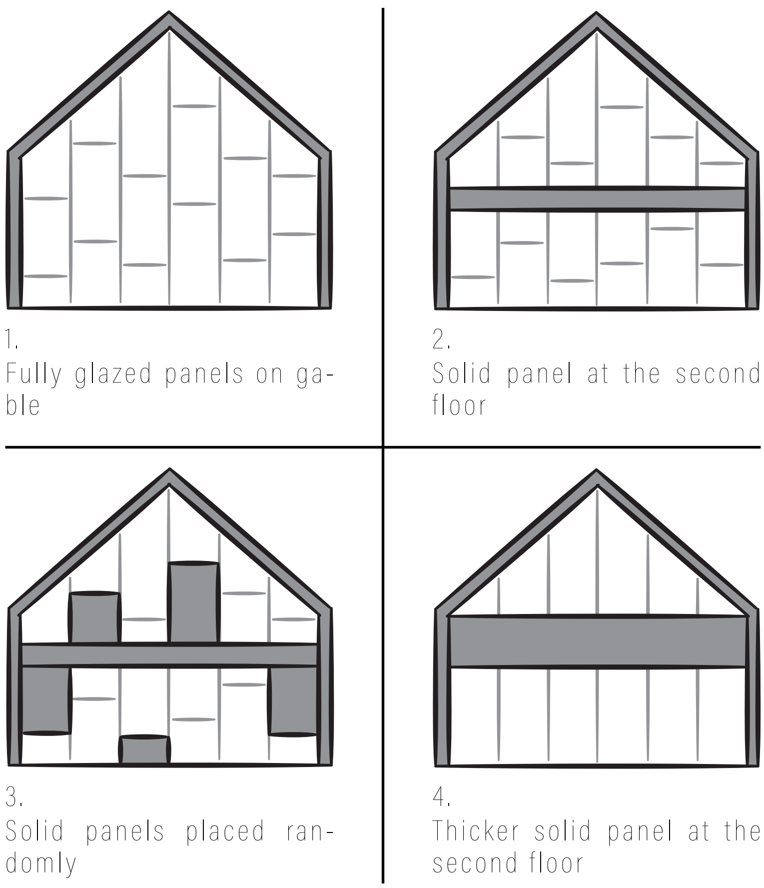


FIG.51 Common house gable sketching

The daylight process in the common house has been an obstacle especially in the stable because of the change of use that gave a higher demand for daylight. The first floor has also been difficult because of the obstacle of how to break the thatched roof when the thickness of the roof only would enhance the cutted shape. The amount of windows in the courtyard was minimal to visualize the building embracing the courtyard.

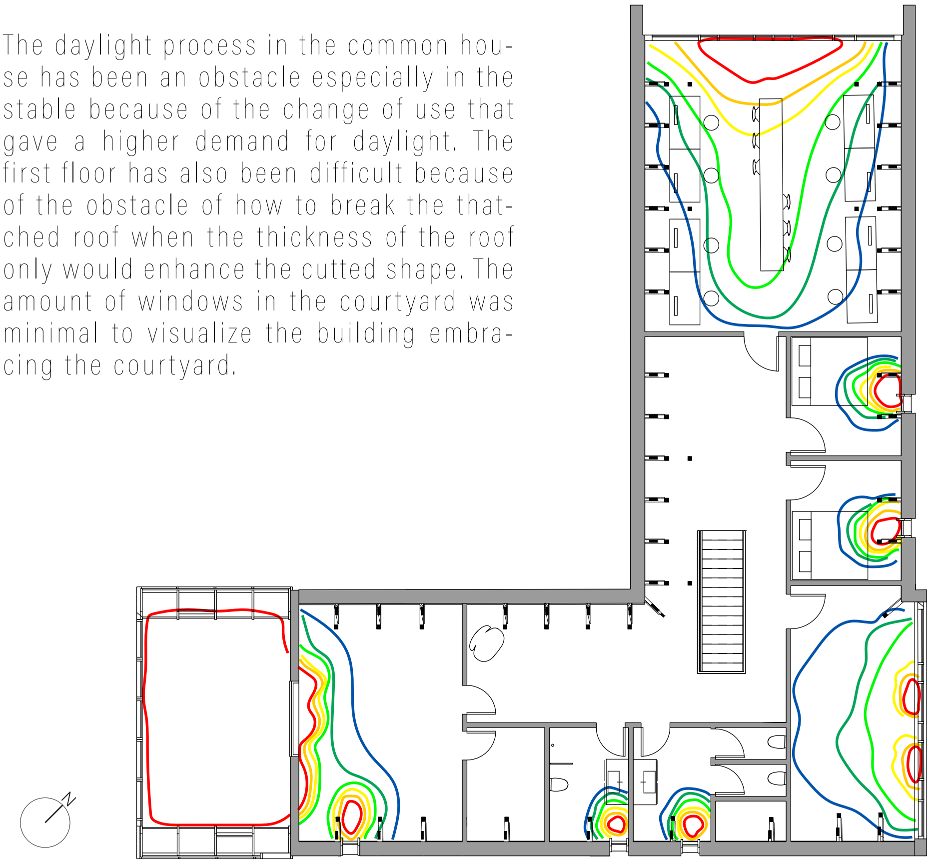


FIG.52 1:200 2.floor without skylight

The corridor of the first floor was lacking daylight and while trying to keep the concept of a solid volume embracing the courtyard skylights was integrated. These skylights contributed with an even distributed daylight in the corridors. When placing a skylight on thatched roof it can not be flat with the roof surface which might result in some shading during the winter season.

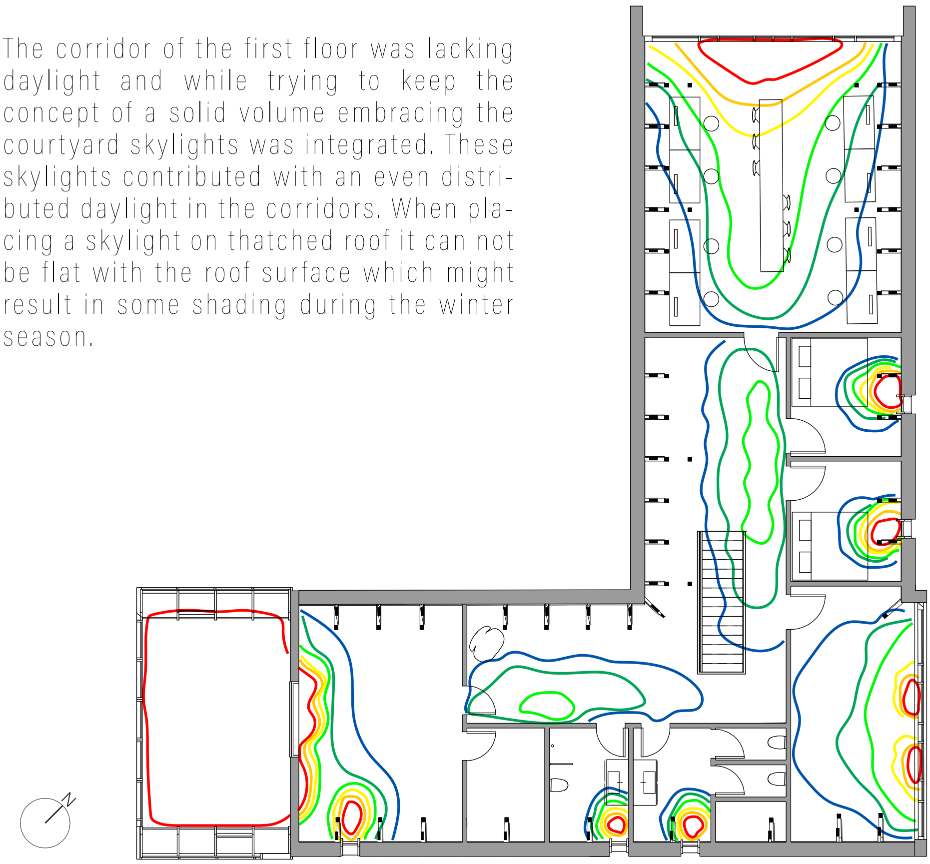


FIG.53 1:200 2.floor with skylight

STABLE CONSTRUCTION

As mentioned earlier the stable of the farm will be renovated into a common dining area for the residents. It should be able to contain around 70 people but at the same time also be comfortable for relaxing for fewer people. The second floor of the stable will be a new function that requires a stronger bearing system on the first floor. As shown in fig. 54 the existing columns are randomly placed but forms a small passage in the middle of the stable with feeding strays for cows on each side. This atmosphere will be translated into the common dining area by redefining the passage with columns. The columns will also help divide the large room without losing the visible connection across the room. The distance between the columns were tested through 3D visualization to see their effect on the spatial understanding. With three columns there was a need for increasing the cross section of the columns (fig. 55). The proposal with five columns would divide the room too much (fig. 57) The proposal with four columns (fig. 56) formed the feeling of the passage and still gave the spatial sense of one common room. The calculation can be seen in appendix 15.

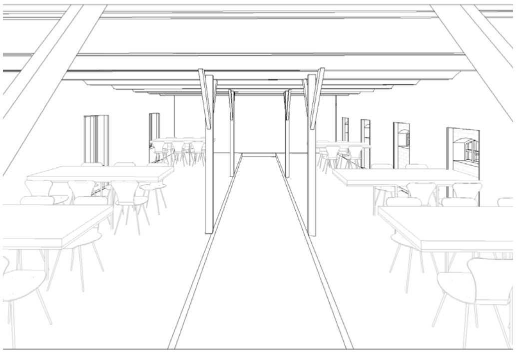


FIG.55 The dining hall with 3 columns

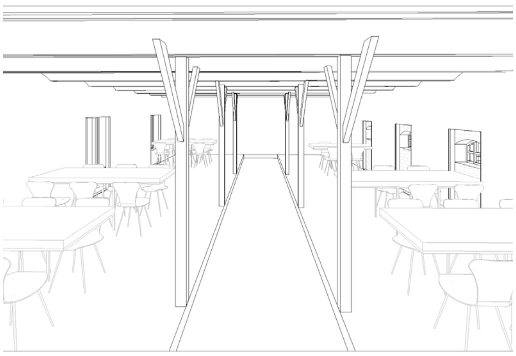


FIG.56 The dining hall with 4 columns

FIG.54 The existing stable

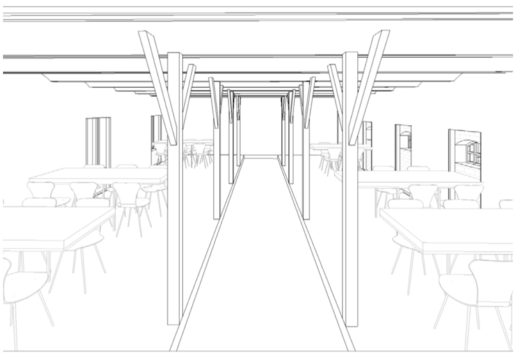


FIG.57 The dining hall with 5 columns

The initial LCA calculations made the decision of a wood bearing construction which led to an investigation of the different wood sorts. The wood sorts were validated on their cover percentage in Denmark, to avoid influence on the danish biodiversity. Furthermore, their lifespan, duration class, strength, and embodied carbon. LCAByg was used to receive an overview of the wood sorts ability to contain carbon and surprisingly, there was a large difference which is shown in the bar chart below.
The choice of working further with beech was made because of its good structural strengths, large cover percentage in Denmark, and the low CO2 emission.

	Pine	Spruce	Cedar	Larch	Oak	Beech
Lifespan [years] Contact with dirt and moist	50	50+	15-20	500	50-125	5-10
Covered area [%]	10,5	13,35	4,9	4,9	11,65	12,7
Duration classes	3-4	4-5	2-3	3-4	2	5
Compressive strength fiber direction [MPa]	45-47	33-42	35	47-54	53-65	52-56

FIG.58 Comparsion of different wood sorts

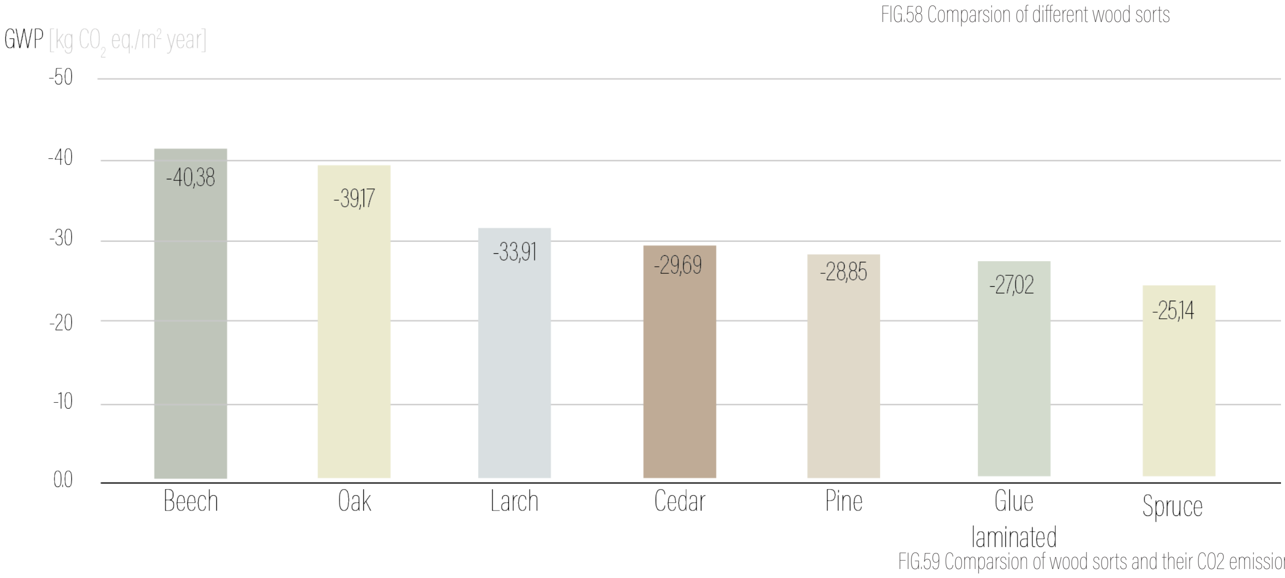
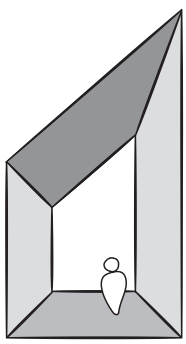


FIG.59 Comparsion of wood sorts and their CO2 emission

DWELLINGS

PLAN LAYOUT ON UNIT B

The layout of the dwellings has changed along with the masterplan, but one element has remained since the beginning. As mentioned earlier, the dwellings will be designed with 40% less floor area than average danish homes. They will contain the essential need for a house but share functions such as laundry, and office space at the common house. Previous sketching can be seen in appendix 6. The courtyard connects the entrances of the dwellings to increase casual encounters between the residents. To enhance this connection between the residents the kitchen was placed toward the courtyard as seen in fig. 60 and 61. In fig. 62 the bedrooms were placed towards the courtyard which exposed the most intimate space in the dwelling to the common courtyard. Both the dwelling in fig. 61 and 62 have a full gable in the living room which makes the saddleroof shape visible. The dwelling in fig. 60 have half a gable that has other spatial qualities. To strengthen the connection between family members lead to choosing a plan with connected kitchen and living room. Based on this investigation it was decided to go further with the plan layout from illu 1. to get the connected common space and the connection between the kitchen and the courtyard. Unit A will have the same overall layout but Unit C due to its size will have a layout mixed between the plan from fig. 60 and 61. This can be seen in appendix 7



1. By having the rooms and toilet in one side it creates a connected livinroom and kitchen.

FIG.60 1:150 First proposal on plan layout

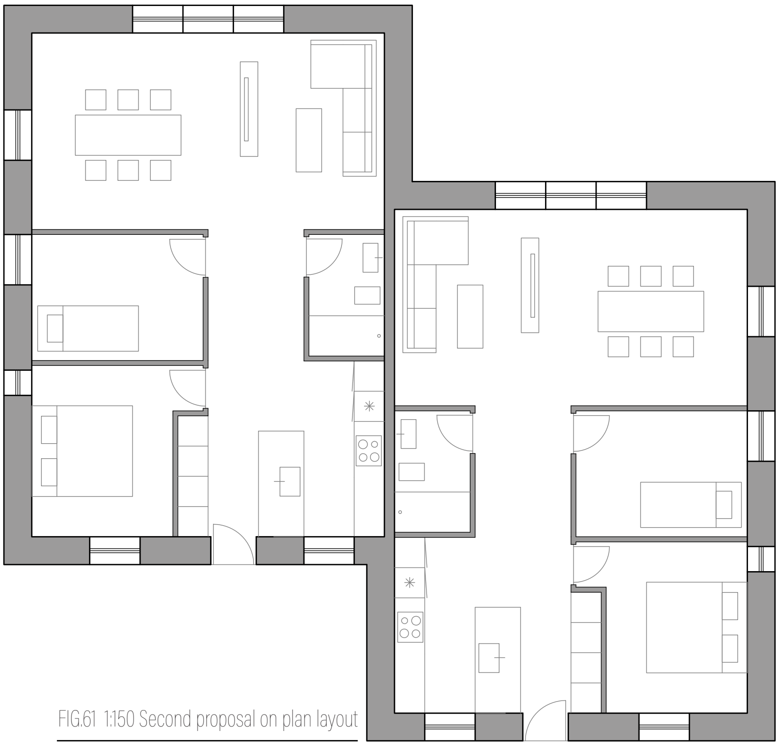
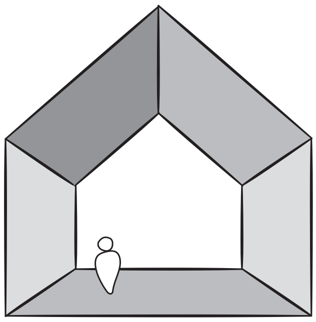
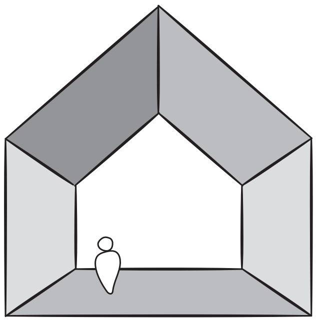


FIG.61 1:150 Second proposal on plan layout



2. The livingroom are placed toward the gable with the view of the landscape and the kitchen at the courtyard.

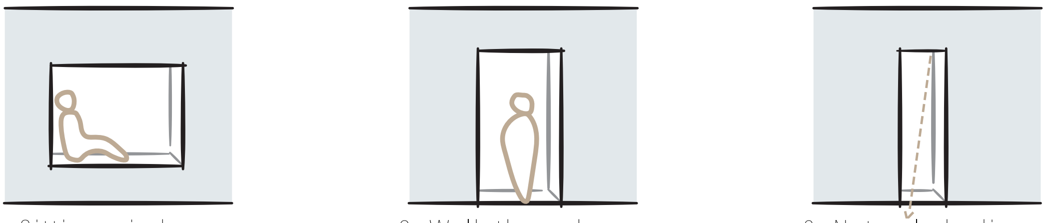
FIG.62 1:150 Third proposal on plan layout



3. The livingroom and kitchen are placed at the gable with view of the landscape.

WINDOW DESIGN

The function of the room has a lot to say of placement and size of the windows. In bedrooms there are a higher demand for privacy, which is why the windows will be elevated (ill. 1) from the ground. If the window is wide enough it can also be used as a furniture. Windows that are wide that touches the floor can be used as a terrace door (ill. 2). A narrow window that touches the floor are ideal for letting sun in but also creating a natural shading when its plane with the interior wall. At fig. 64 the gable seemed simple because of the large façade cladding and large windows. At the side it seems compact for the wide windows. The window in fig. 67 created a lighter expression by connecting the facade and roof. illu 3 shows windows that emphasize the form of the building. To avoid overheating the gable will have windows that provides a good view with a minor character.



1. Sitting window 2. Walk through 3. Natural shading

FIG.63 Window design strategies

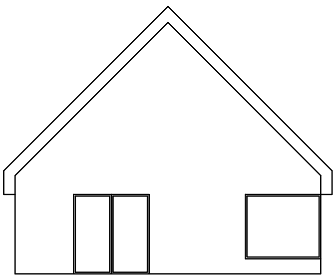


FIG.64 1:200 Two windows connected in a corner to create a wide view

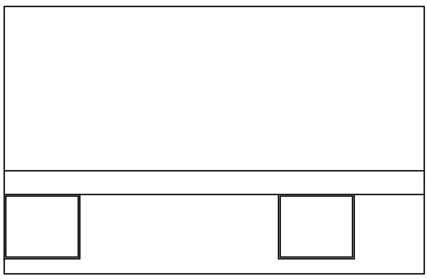


FIG.65 1:200 Windows lifted from the floor creating seating area in the window frame

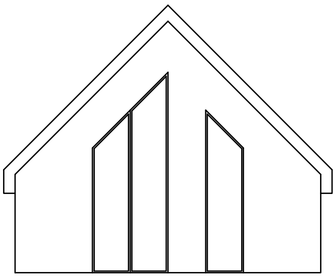


FIG.66 1:200 Long windows mimicking the form of the gable

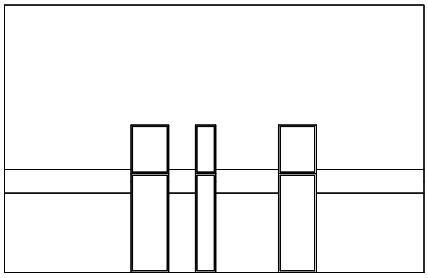


FIG.67 1:200 The long windows creates a connection between the facade and roof

DAYLIGHT IN UNIT C

FIG.68 1:200 Daylight in unit C without skylight

FIG.69 1:200 Daylight in unit C with skylight

The dwellings will be designed with around 15% windows of the wall area to minimize the energy consumption, and overheating. To ensure that 15% windows would give the dwellings the needed daylight, unit C was modelled in velux which is the most critical dwelling because of its length. Fig 68 shows Unit C with 13% windows. The average daylight in the living room is 1,8% and in the kitchen/dining area 0,8%. This is not enough in the kitchen/dining area if the goal is to get 3% daylight on half of the relevant floor area (Bygingsreglementet, n.d.). To get enough daylight at second floor a skylight would be placed across the common area as shown in fig. 69 which improves the daylight with 2,2% in the living room and 1,4% in the kitchen with only a deviation on 0,1% is acceptable. At the first floor there could be implemented an extra window above the sink.

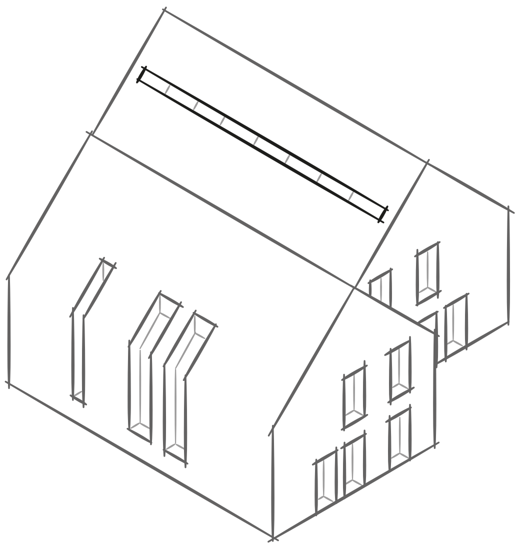


FIG.70 Unit C with skylight

SHADING STRATEGIES

The most critical dwelling concerning indoor comfort was a unit A with south oriented gable and was therefore modelled in Bsim for further investigation. One of the main problems were overheating in the summer. Four different cooling strategies were tested in Bsim, and the following results can be seen in the scheme. They are valued upon the energy consumption calculated in Be18 and the overtemperature in Be18 and BSim. Natural ventilation has the biggest effect but does not cover the demand. Therefore, the dwellings will be designed with other cooling strategies as well where appearance also will play an important role.

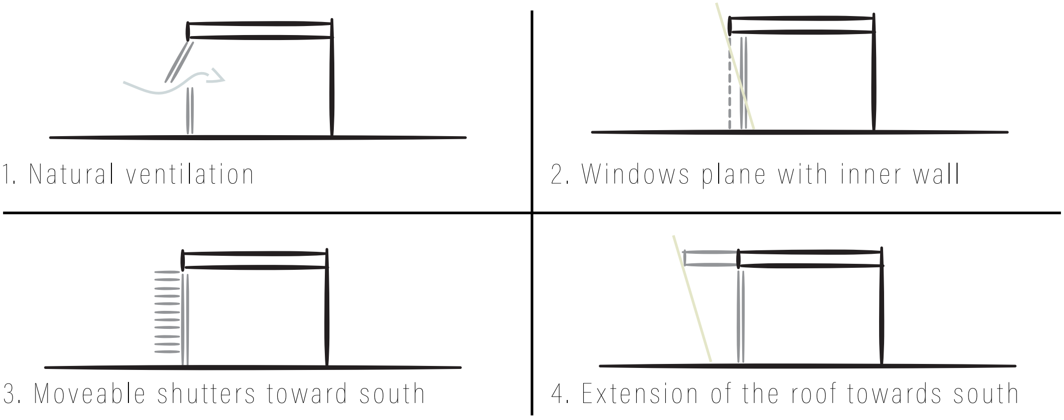


FIG.71 Shading strategies

	Be18		BSim	
Cooling strategies	The energy used to remove the excess heat [kWh/m² pr. year]	Energy demand for Unit A and B together [kWh/m² pr. year]	Hours above 27° pr. year [< 100 hours]	Hours above 28° pr. year [< 25 hours]
1.	4,2	32,6	69	32
2.	19,2	45,9	180	95
3.	12,4	41	122	59
4.	12,7	41,6	136	62

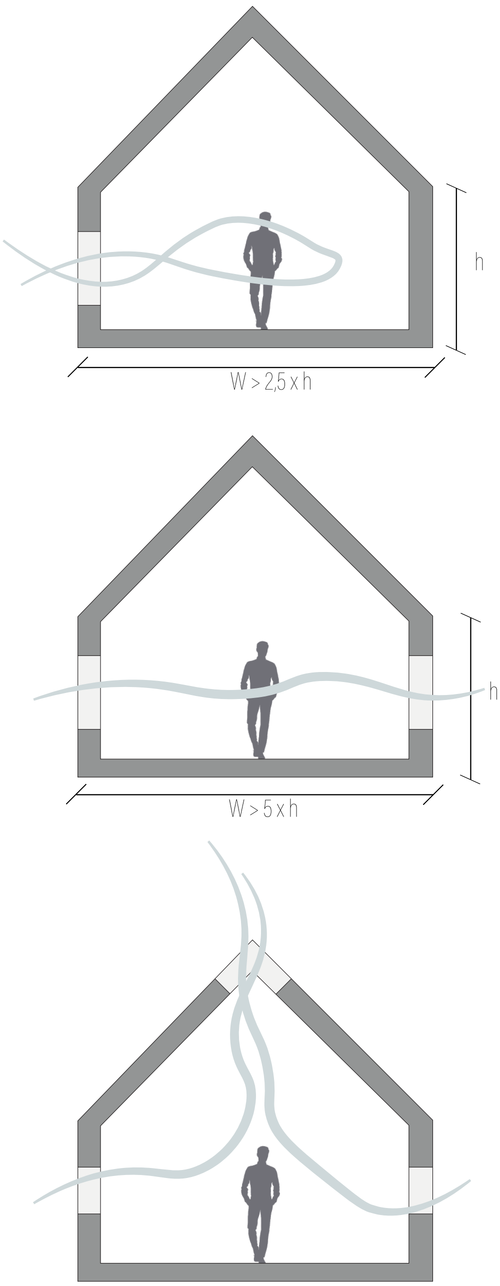


FIG.72 Natural ventilation strategies

There has been investigated different natural ventilation strategies and trying to integrate them into the new building volumes and the existing farm. Since, the consideration of having all the rooms along one side in the dwellings, it would be preferable to use single sided ventilation.

Cross ventilation could be used in the common building, in the dining area and living area if the ceiling height allows it. Cross ventilation would also be able in the dwellings, if a door to the bedroom is open and thereby create draft.

While, considering the idea of having a skylight because of lack of daylight in the dwellings and the common house, it could be possible to have stack ventilation. Stack ventilation is most efficient when the room has many people to create buoyancy. Therefore, this would most likely be more efficient in the common house.

FACADE MATERIALS

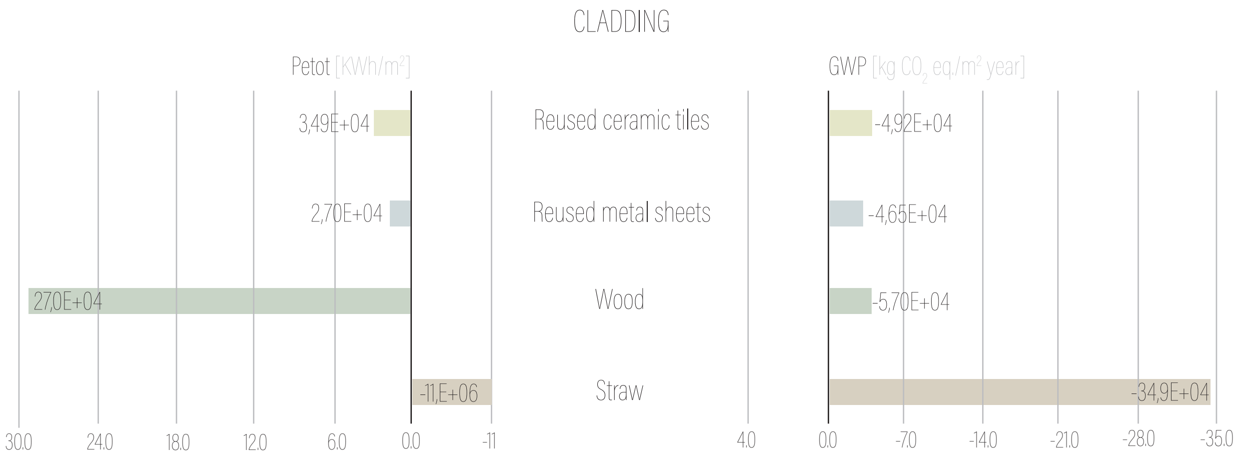
The facades of the dwelling were designed based on the analysis concerning biobased- and demolished materials where further investigation can be seen in appendix 8. Both the dwellings and the common house will have thatched roofing to create a link between the existing- and new buildings. Thatched roofing was also chosen because of its good results in LCA and the relation to traditional building techniques. Wood cladding was chosen to the facades that would be weathered with the thatched roof and thereby have a coherence. The cladding will be vertically oriented to enhance the long windows. Around the dwellings there will be gravel on the ground to minimize moisture damage done to the lower part of the wood.

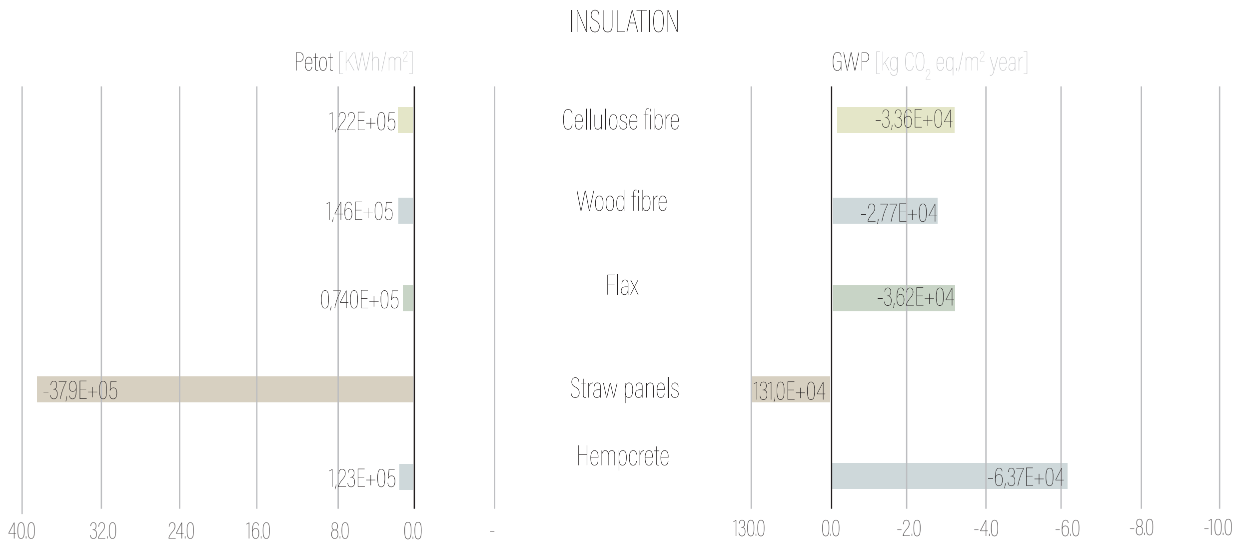
As seen in fig. 73 and 74, different designs were made with straw and wood. Fig. 73 shows a more classic thatched roof with an overhang, and wood on the facades. For a more modern and clean expression the straw continues on the sides and the fully wood covered cladding on the gables that hides the straw as seen in fig. 74. When increasing the amount of thatched roofing it improves the life cycle assessment as well. The decision of letting the roof material continue on the walls improved the LCA calculations and furthermore it expresses a traditional building technique redesigned in a modern time. Additional LCA calculation can be seen in appendix 9.

FIG.73 Classic thatched roof with wood cladding

FIG.74 Modern twist to a classic building technic

LCA OF CLADDING AND INSULATION ON UNIT B





THE COURTYARD

The co-housing has four clusters that each contains four building volumes with 6 dwellings. The four building volumes are placed in front of each other with an angel, creating a courtyard between the buildings. This space is optimal for the residents of the cluster to use for casual encounter and common activities like common meals. A front yard will be placed in front of each entrance to create a transition zone between the private dwelling and the semi-public courtyard. The transition zone will seem more natural by having the rainwater drainage as a boundary between the courtyard and the front yard as seen in fig.76.

Alongside designing the materials of the facades, the courtyard was also in the making. The process can be seen in appendix 10. The front yard will be made in the same wood cladding as the facades, and the rest of the courtyard will be gravel with connection to the parking lot (fig. 77).

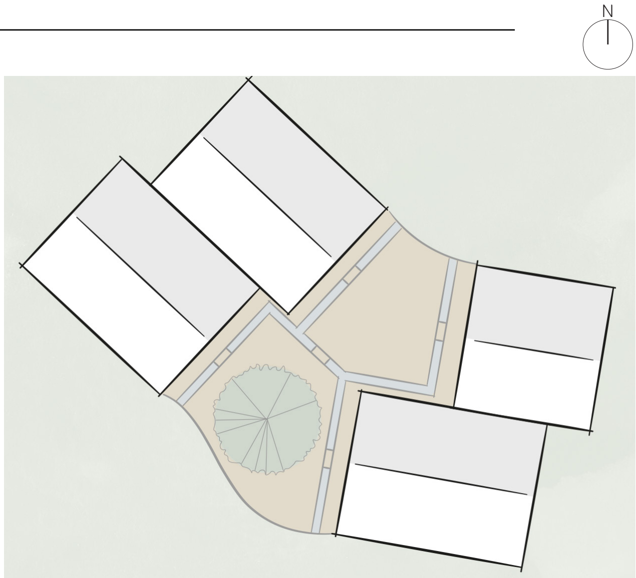


FIG.76 Courtyard with rainwater drainage

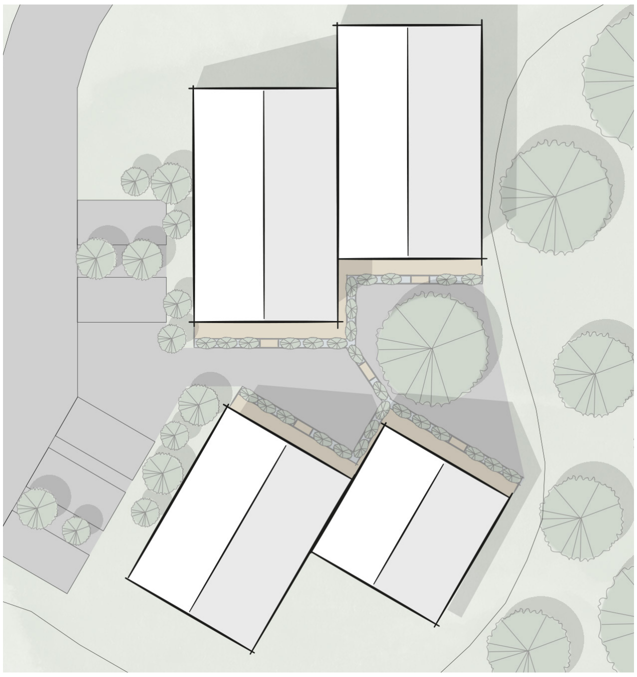


FIG.77 Courtyard connected to the parking lot

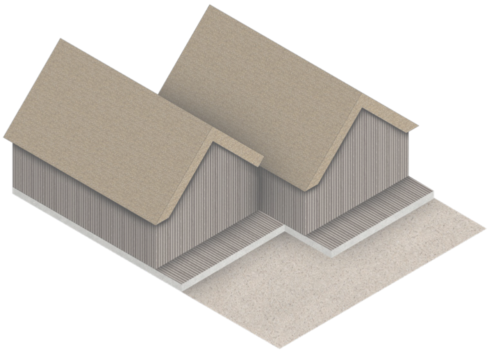


FIG.75 The connection between the materials on the facades and the courtyard

INTERIOR MATERIALS

There has been an investigation of the interior materials in the dwellings, and mainly of the longitudinal interior wall as shown in the fig78-80. By constructing this wall in unfired clay bricks and clay mortar it has the properties of acting as a thermal mass that will contribute to thermal- and atmospheric comfort through a more even temperature and act as a moisture bufferzone. The color and texture of the wall had a high influence on the interior rooms and their appearance and the wall should furthermore relate to the color scheme of the visible roof construction. Luckily, clay mortar can be bought in a wide range of colors and textures which resulted in an spatial visualization process of the wall with different colors and textures to get insight in the atmosphere of the rooms (more in appendix 11.)

The floors were decided beforehand to be constructed in reused concrete to increase the amount of thermal mass and to make floor heating more efficient. Concrete and clay are materials with high thermal mass and therefore have good properties of storing heat. This means that during a day, the outdoor temperature will vary a lot, but the material will release heat when it is cold and emit heat when it is warm and thereby stabilizing the temperature.

FIG.78 A plain clay surface

FIG.79 A cracked clay surface

FIG.80 A shoveled clay surface

CHAPTER CONTENT

This chapter contains the final outcome and results of the master thesis. The site and urban area is presented, which is followed by a more detailed presentation for the common house and the dwellings. The presentaion include technical- and architectural considerations.

PRESENTATION

FIG.81 Stacked used bricks

LILLEÅGAARDEN

Welcome to Lilleågaarden, a co-housing community with a social- and sustainable lifestyle for all family sizes and ages. With a location just at the edge of Hadsten you are close to common necessities and even closer to the beautiful hilly fields, Lilleåen and Sølund forest. Lilleågaarden consists of 24 dwellings ranging from 50 sqm. to 80 sqm. The co-housing has a large common house with shared facilities, such as laundry, office spaces, living room, kitchen, and other rooms for creative minds. Lilleågaarden has outdoor activities for all ages such as animal care, farming, playgrounds, outdoor workout area and good walking trails surrounded by wild nature.

FIG.82 1:1000 Masterplan

FIG.83 Common house - courtyard

The Views and sightlines have been very important through the whole process. The view from the parking near the lake, embraces the farm between the new dwellings which also embraces the idea of the co-housing (fig.86). The views of the dwellings are more focused on the surrounding nature mainly facing the road or the field. The living room of the dwellings is the room with the great view. Some dwellings was not able to have a view to the surrounding nature, but has a view to the wild vegetation on site.

FIG.84 1:200 Site section AA

FIG.85 1:200 Site section BB

FIG.86 1:200 Site section CC

FIG.87 Path towards common house

URBAN AREAS

Most of the urban functions and activities are in the recreative area between the buildings. This is functions such as Alpacas, chickens, outdoor fitness, and playgrounds. Outside of this area there are farming lands, fruit orchard, greenhouse, and a fireplace. Some of the functions needs maintenance and care to function efficiently. This highly depends on the residents and their initiative to take care of the place and hand out chores. Many of the functions that needs maintenance also contributes with food and thereby creates a feeling of being self-sufficient and taking care of one another. The urban functions have different values, while some functions activate the user, others offers relaxation and a nice view.

The pavements on site either comes from reused materials or natural materials. The pavement in the courtyard of the common house, is reused bricks from the old fire station in Hadsten that was currently demolished. The parking areas are made in reinforced grass, to have a green parking area while still being useful and safe and solid to drive on. The concrete is reused concrete from a bridge in Hadsten that recently was demolished. The paths on site, are made of rock powder, which gives a solid ground for walking, running, and bicycling.

The vegetation is mainly wild nature, that contributes and enhance the surrounding microclimate. Furthermore, there will be edible plants, such as fruit trees and berries, for the residents and animals. The rainwater wetland, will remind of the climate along Lilleåen, with high reeds and shives, where the water containment will vary depending on the weather.

FIG.88 Dwellings coutyyard in the winter

FIG.89 Dwellings coutyyard in the summer

PAVEMENTS

Reused bricks in the common courtyard

Reinforced grass on parking areas

Rock powder pathways, workout- and playground area

FIG.90 Urban functions and activities

COMMON HOUSE

The existing farm on site is transformed into the common house. The common house consists of shared facilities that are shared between the residents. The first floor has the more active and everyday life functions that needs to be easily accessible but also to radiate the buzzing life inside to the curious passers-by. On the first floor there are common living room, shared laundry toilets, common kitchen, and dining area. Furthermore, there is an extension of the farm in shape of a greenhouse. The second floor has functions that rather needs more privacy or calmness for immersion. The functions of the second floor are the shared office area, guests' rooms, showers, toilets, creative room, children's room.

The facades facing the new dwellings mimics the language of the window belts while still reflecting a different function through the material use. The window placement is highly affected by previous window holes to minimizing demolishing materials that still has some good years left. The walls are not changed and stands as red bricks with a covering lime surface. The asbestine roof has been replaced with a thatched roof since there was a need for insulation on the second floor but also because of the harmful toxins in the asbestine tiles. The facades facing the courtyard is more solid and less transparent, to trigger a feeling of being embraced by the building. Here, the existing stable windows are visible that tells a story of the previous function and life at the farm. The greenhouse extension is made of reused glass, and therefore consists of random placed mullions. The thatched roof has an overhang at the gables to act as natural shading for the large, glazed panels.

FIG.91 1:200 Longitudinal section DD

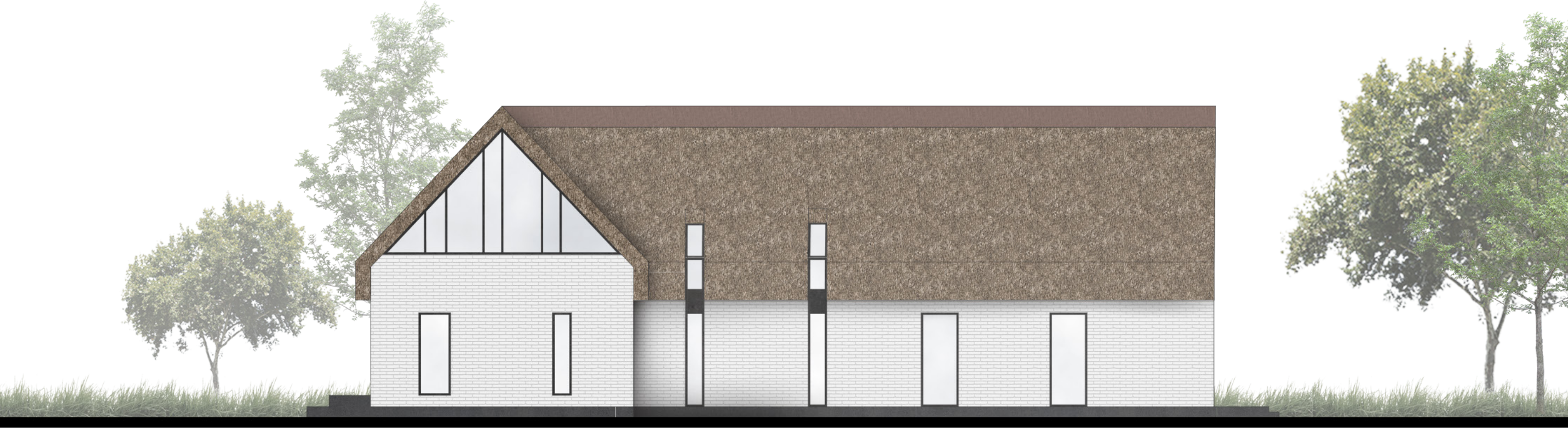


FIG.92 1:200 North-east facade

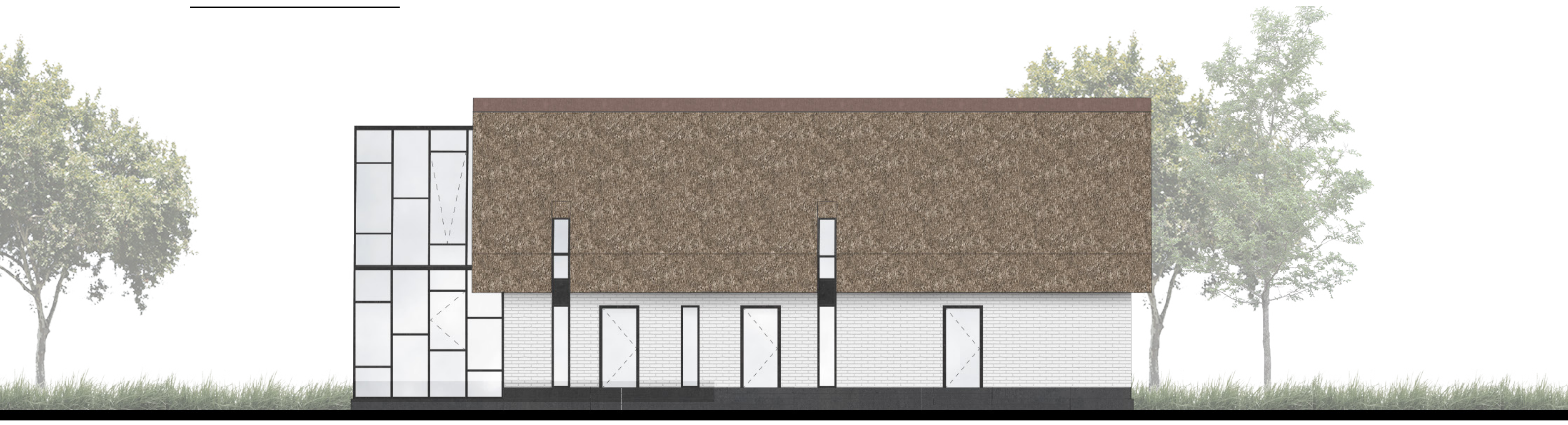


FIG.93 1:200 South-east facade

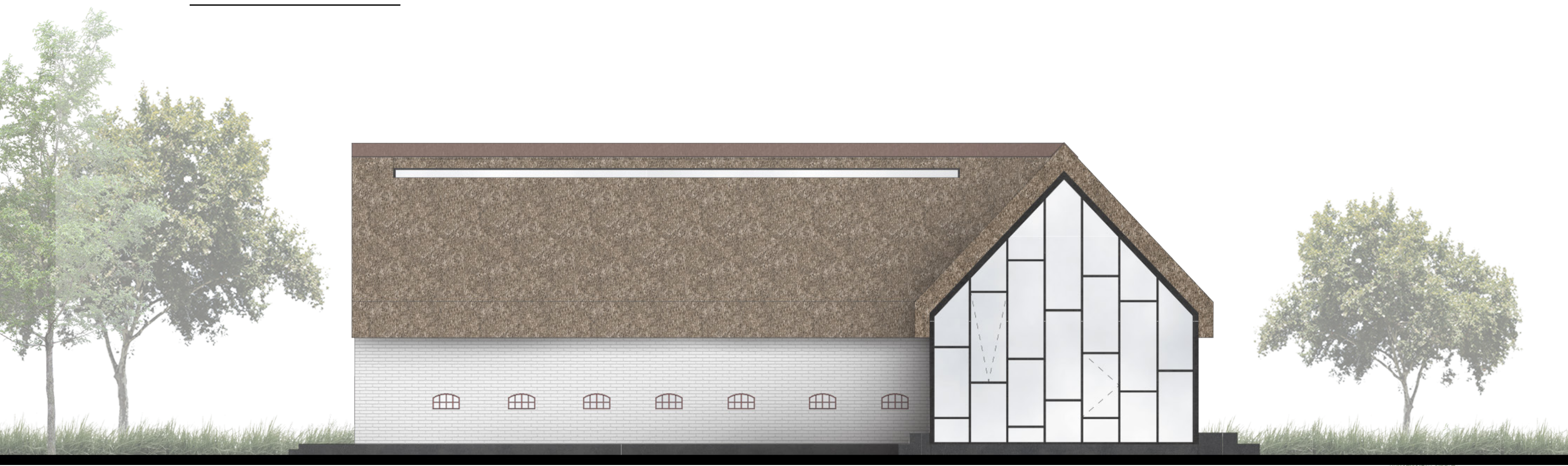


FIG.94 1:200 South-west facade

FIG.95 1:200 North -west facade

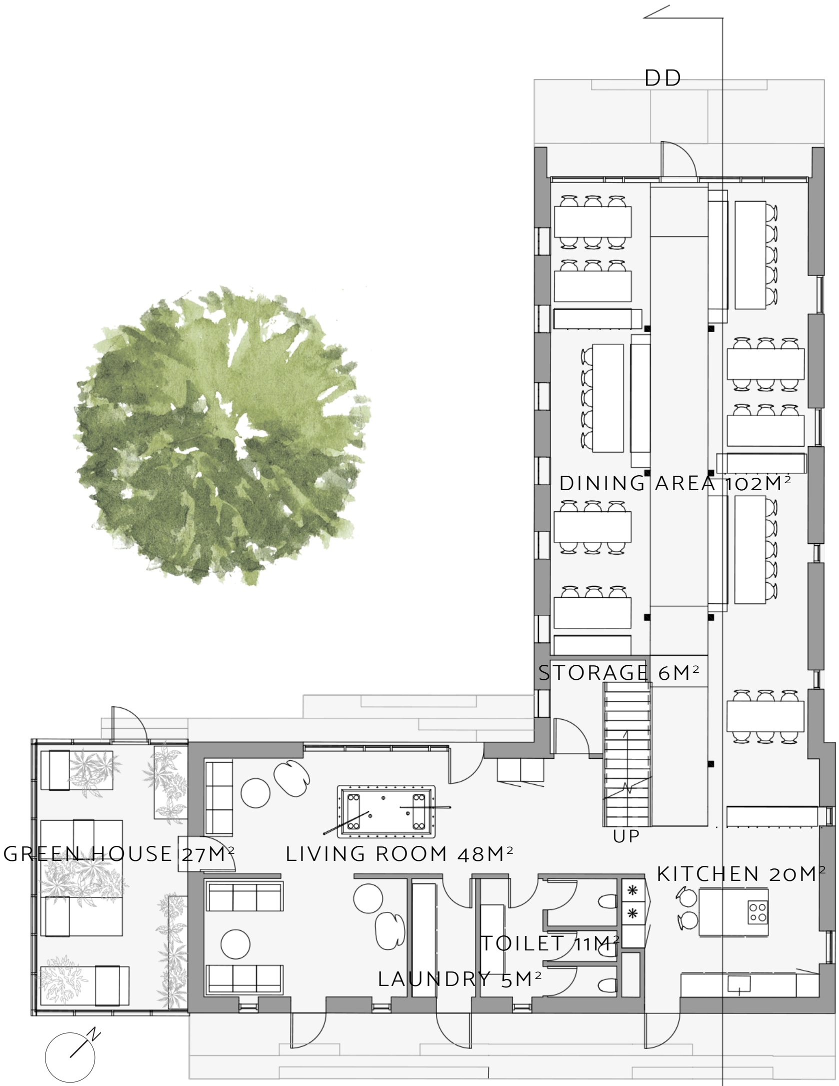


FIG.96 1:200 1. floor

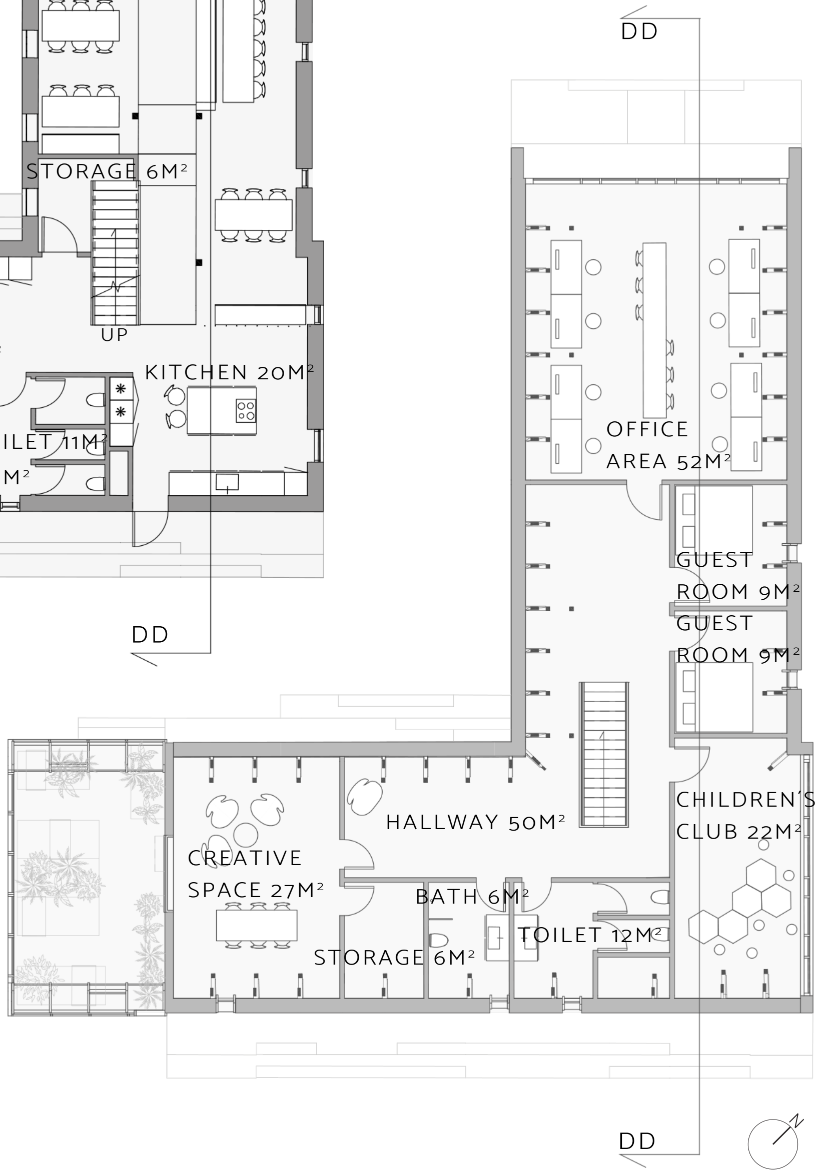


FIG.97 1:200 2 .floor

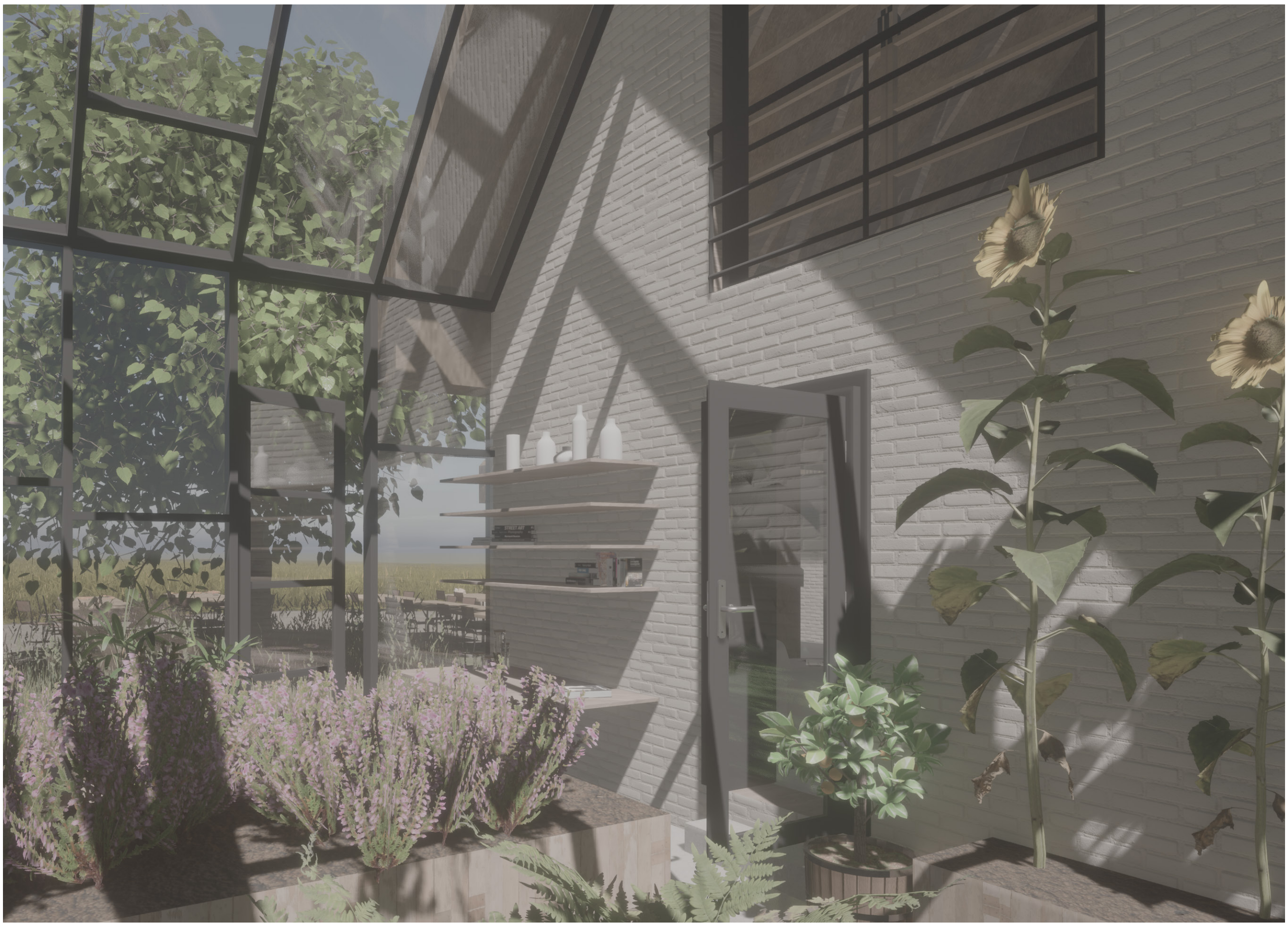


FIG.98 Green house

FIG.99 Office area

FIG.100 Dining area

CONSTRUCTION

The columns in the stable of the common house have been the construction in focus of this project. The column placement has been systematized for an easier calculation process. The cross section of the columns is 150X150mm which is slightly thicker than the original columns. The cross section has increased due to change of function on the second floor and because of the material. The columns are made of beech, which has a high level of embodied carbon and has therefore been prioritized more, than a slimmer cross section.

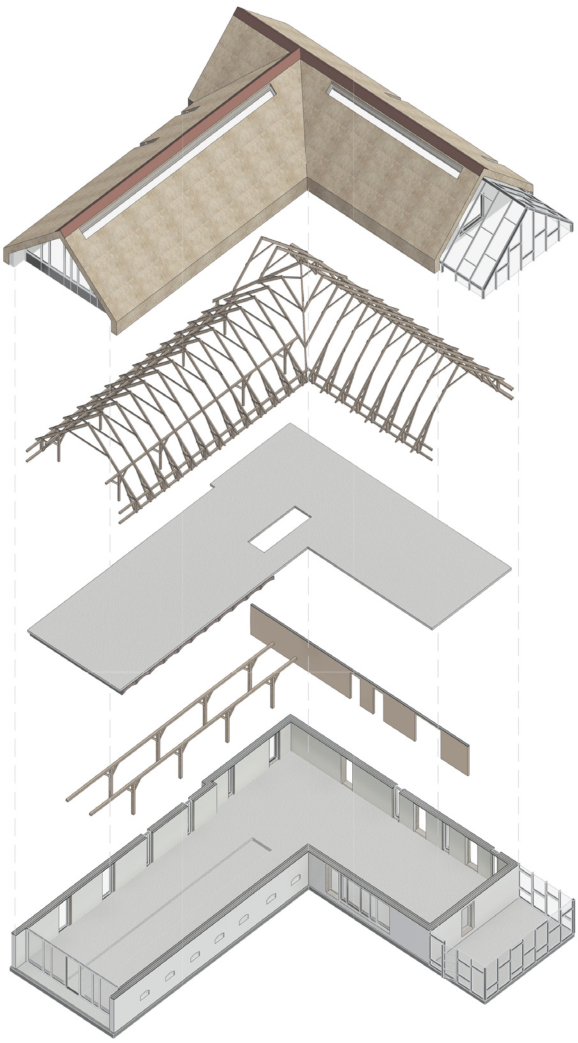


FIG.101 Exploded view of the construction

The mechanical ventilation shaft is placed close to the kitchen and toilets. The ventilation distributes fresh air to the living area, common dining area, guest rooms, creative room, office space, and children room. There is exhaust from the toilets, kitchen, common dining area, office space, creative room, childrens room, and storages. The placement of the ventilation pipes in the common dining area was difficult because of the valved ceiling.
For natural ventilation, it is possible with stack ventilation through the skylight, cross ventilation in the living room and single sided ventilation in the guest rooms.

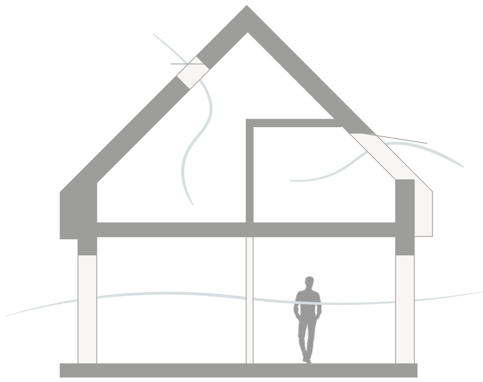


FIG.102 Natural ventilation princip

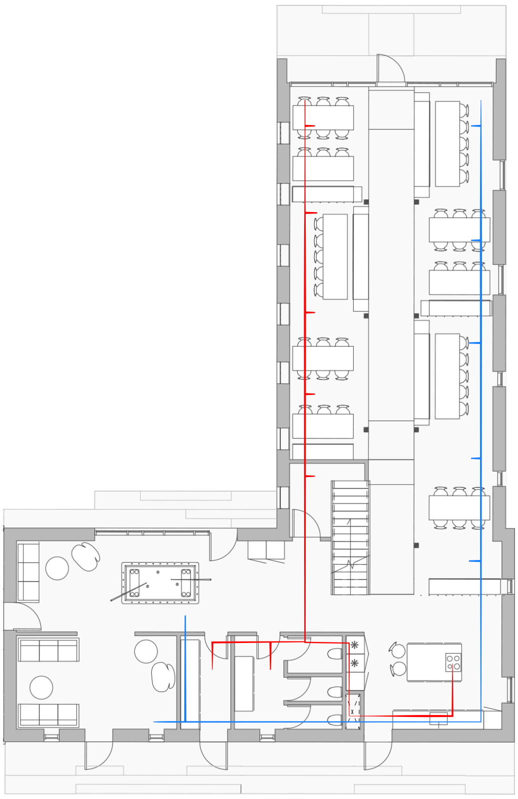


FIG.103 1:250 Mechanical ventilation on 1. floor

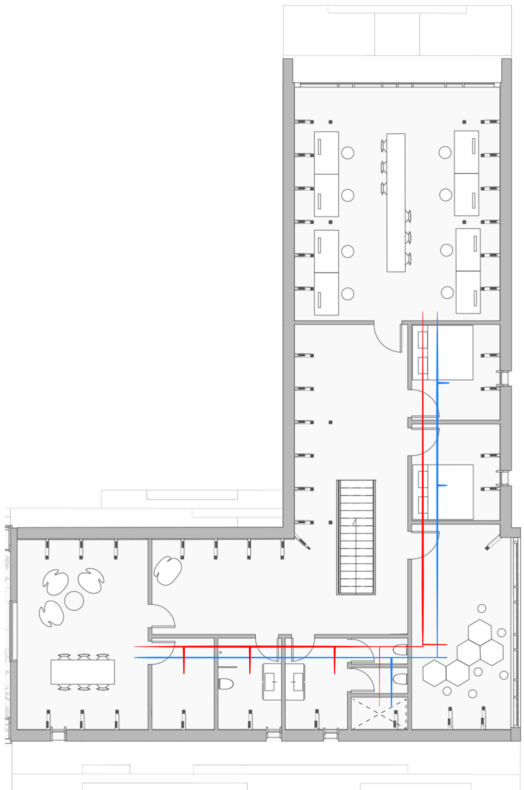


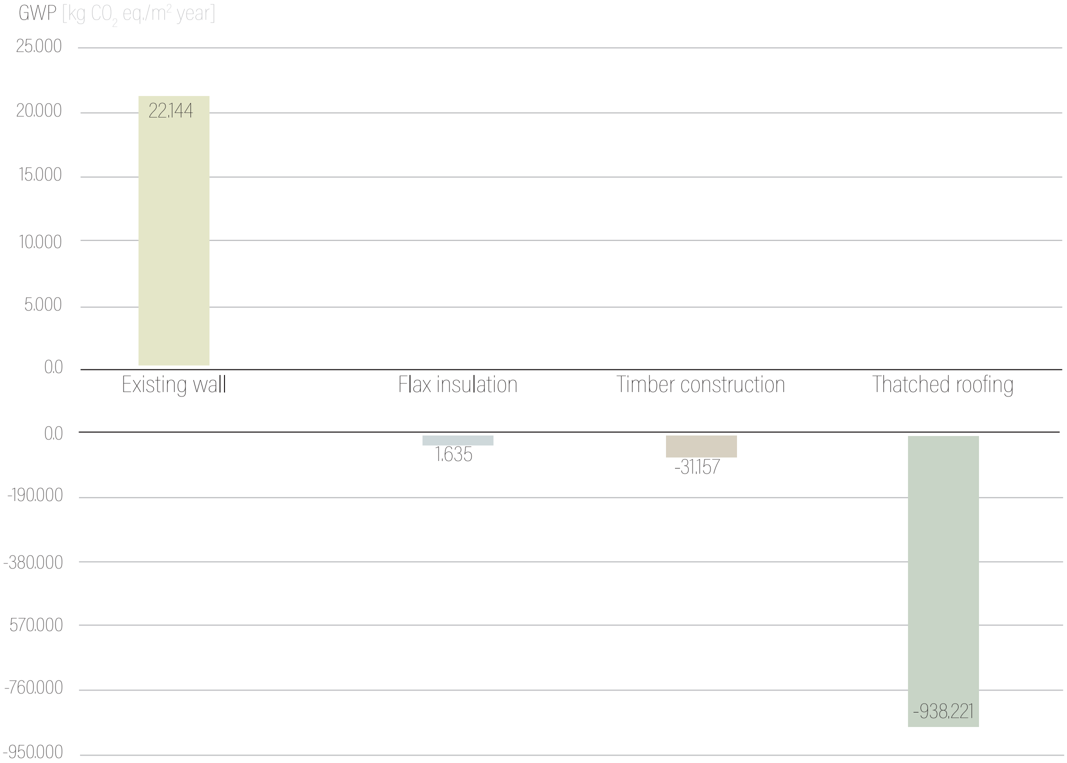
FIG.104 1:250 Mechanical ventilation on 2. floor

TOTAL LIFE CYCLE ASSESSMENT

As shown in the illustration, the hotspot of the CO2 emission is shown. The existing exterior wall has a high CO2 emission, but since this construction was already an existing building part, this can be seen as a “saved” CO2. The thatched roof is the largest negative value because the material has a lot of embodied carbon. Also, by having reeds on the top part of the facades, also helps lowering the building’s total CO2 emission.

RESULT COMMON HOUSE

GWP	ODP	POCP	AP	EP	ADPe	ADPf	PEtot
[kg CO_2 eq.]	[kg R11-eq.]	[kg Ethene eq.]	[kg SO_2 eq.]	[kg Phosphate-eq.]	[kg Sb eq.]	[Mj]	[KWh]
-9,46E+05	5,71E-05	5,74E+03	-1,26E+04	3,52E+01	1,75E+00	2,07E+06	4,36E+06



DETAIL DRAWING

The common house has been insulated on the interior walls, even though this demands a vapor retarder to avoid condensation in the construction. The roof is insulated on the exterior to have a visible roof construction inside the building. This has created some obstacles concerning the connection between the roof and the exterior walls because the vapor retarder needs to be wrapped around the columns and patched up with special tape for vapor retarders. A larger scaled detail drawing can be found in the drawing folder.

RENOVATED WALL

1. 5mm clay mortar
2. 10mm plywood
3. 80mm flax insulation (three layered low energy window)
4. 108mm brick
5. 116mm loose insulation
6. 108mm brick (existing window)

The u-values of the roof is 0,12, the walls are 0,147 and the foundation is 0,201. The material layers of the roof and the foundation can be seen in the drawing floder.

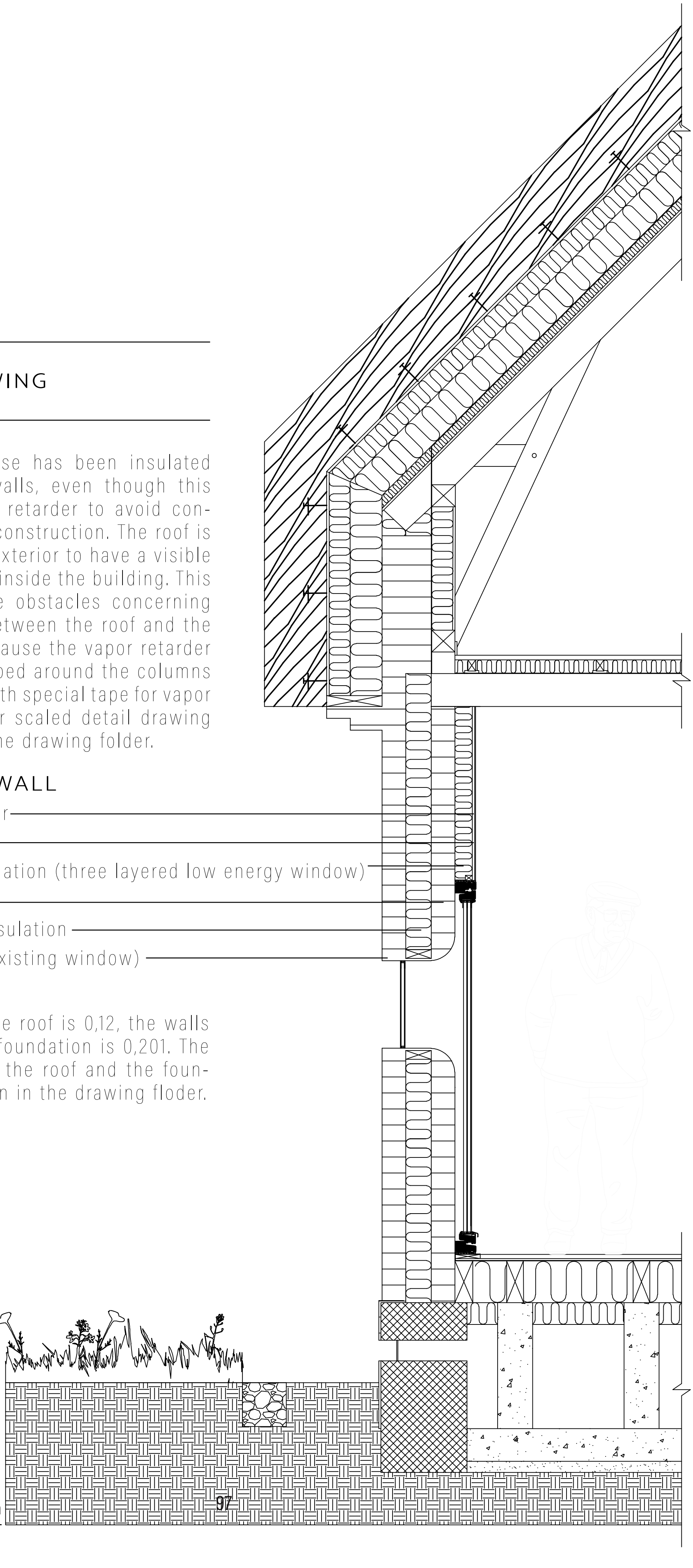


FIG.105 1:25 Detail drawing of renovation

DAYLIGHT

The demand for daylight in the common house was most critical in the stable, because of the small windows. Therefore, large glazed panels were integrated at the gable of the stable. Furthermore, the windows facing the new dwellings were extended to the floor which made the daylight factor reach 3% on the half of the relevant floor area.

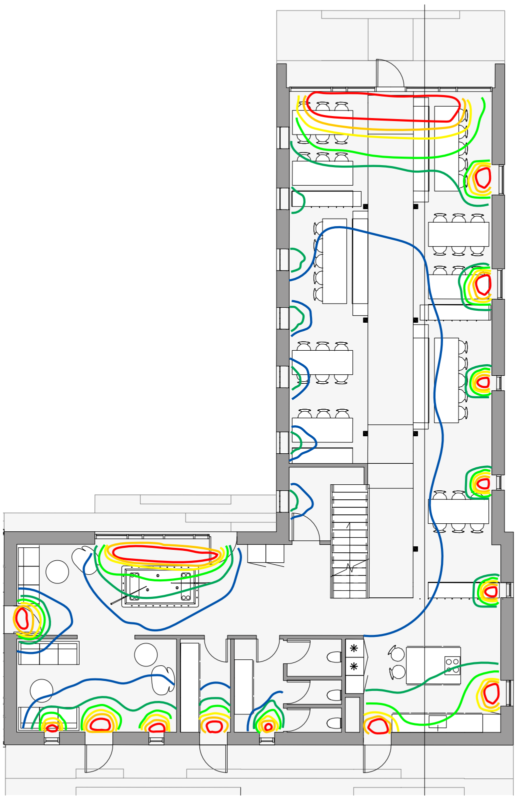


FIG.106 1:200 Daylight on 1. floor

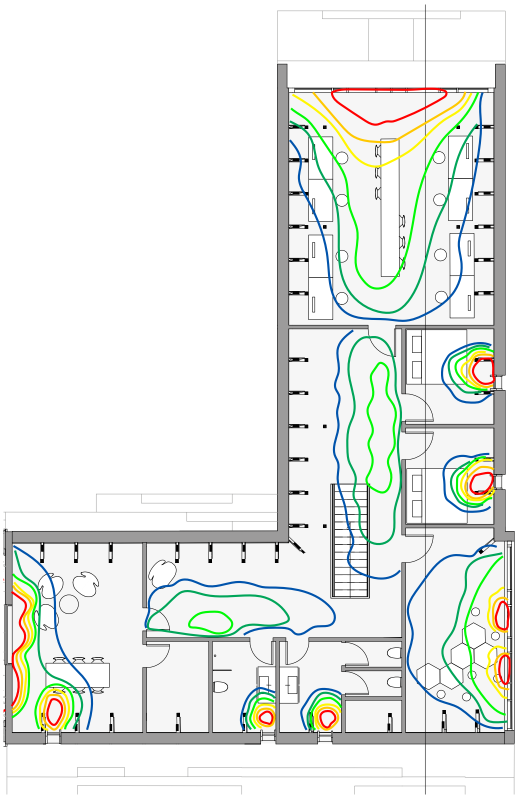


FIG.107 1:200 Daylight on 2. floor

BE18

When energy renovating, optimizing the buildings envelope are a important aspect. The better U-value achieved when renovating the less transmission loss will happen which means less energy will be used to heat up the building. Another aspect of renovating are what aspects of the existing building there will be preserved. Be18 have been used to understand the existing farmhouse's current energy frame. The existing foundation have a ventilated room under the floor. This created a challenge because this ventilated room need to stay ventilated or there is a risk for mold. The renovated foundation therefore doesn't fulfill the U-value from renovation class 1. To compensate for this the roof and exterior wall will be renovated to get a better U-value and thereby fulfill the energy frame for renovation class 1.

The scheme below shows the energy frame before and after renovation. For futher detail see appendix 12. The current energy frame is quite high, but just by renovating the envelope a lot of the energy are maintained. Other than renovating the envelope a new heating system and mechanical ventilation have been applied.

ENERGY REQUIRMENT	
Existing farm house's energy frame	192,8
Renovation class 1	75,3
Total energy requirment	72,4

CONTRIBUTION TO ENERGY REQUIRMENT	
Heat	0,0
El.for operation of the building	38,1
Overheating in the room	0,0
NET REQUIRMENT	
Room heating	13,1
Domestic hot water	14
Cooling	0,0

UNIT C

FACADES & LOCATION ON SITE

Unit C is the largest dwelling in the co-housing community. The shown facades is of a cluster consisting of two unit C. This dwelling has three rooms, a bathroom, kitchen, and living room where the presented unit C is in two levels. The long facades are covered in thatched roofing, and are only broken by the long window glazed belts. The gables are covered in wood cladding, which continues as pavement in the small front yard of the dwellings. The windows on the gable are evenly placed with the same height that gives the facade a certain calmness compared to the more dynamic thatched facades.

FIG.108 1:200 East facade

FIG.109 1:200 South facade

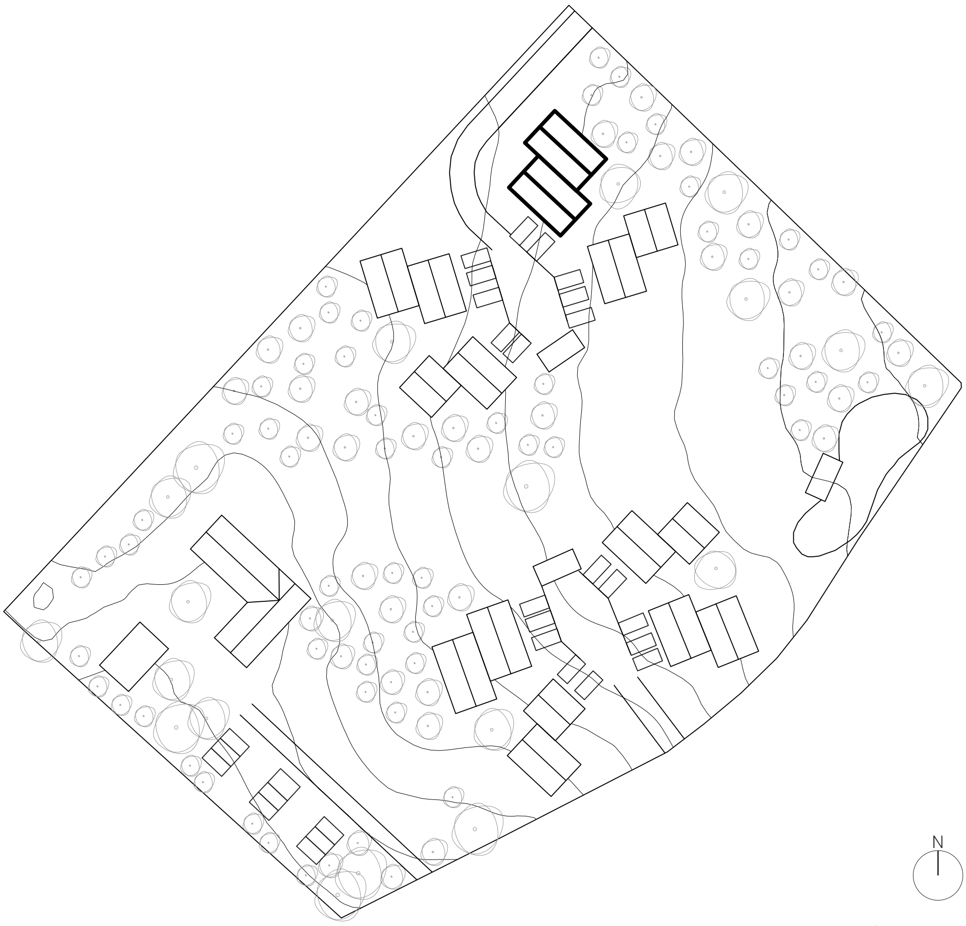


FIG.112 Location of the dwelling

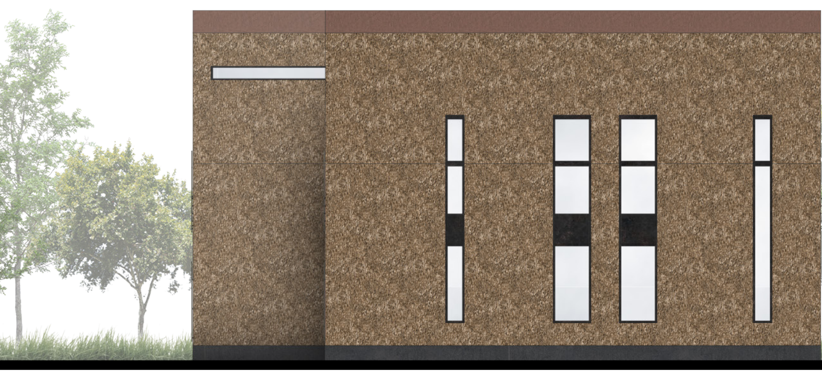


FIG.110 1:200 West facade

FIG.111 1:200 North facade

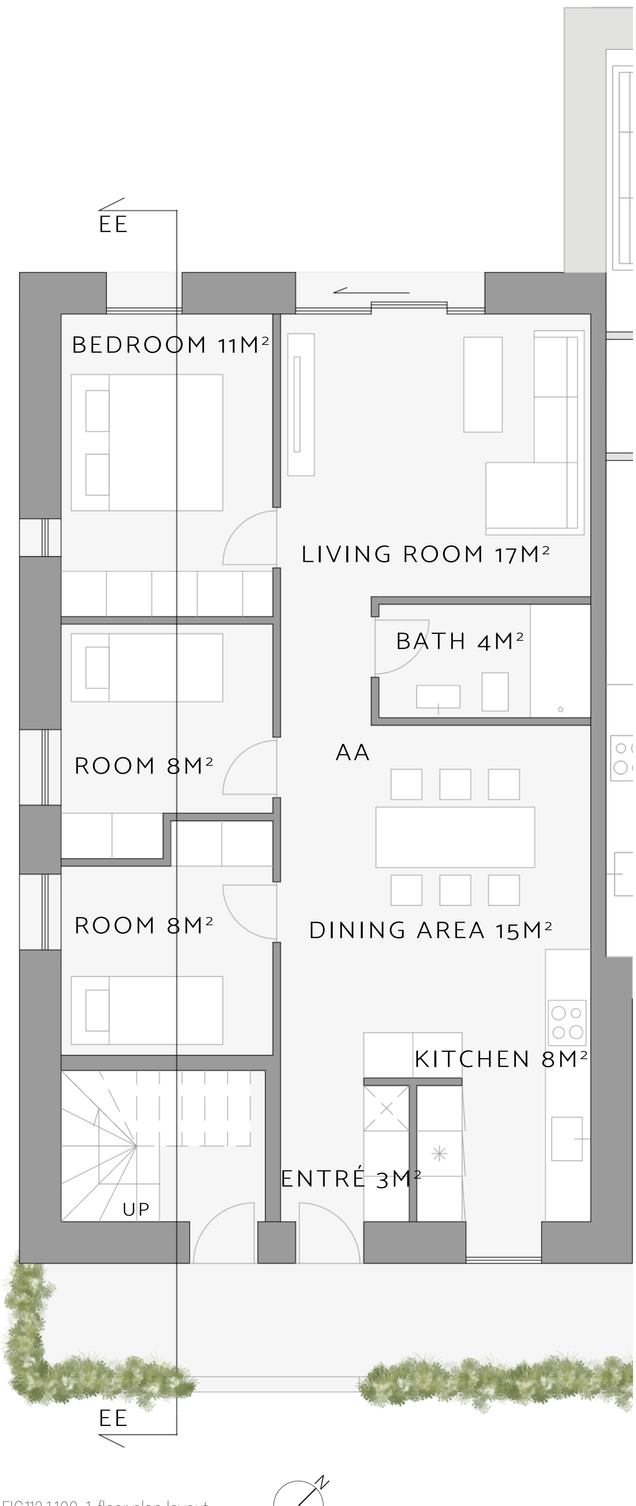


FIG.113 1:100 1. floor plan layout

FIG.114 1:100 2. floor plan layout

As mentioned unit C consists of three bedrooms, one master bedroom and two smaller rooms. All the rooms are placed along one facade for easier ventilation strategy, but also to have the high ceiling in the common kitchen and living room. This is of course only on the second floor, where the common room is on the first floor. Both levels have visible roof/ceiling construction that gives an honest image of the building and contributes with other textures in the dwellings.

Unit type	C
Area Unit A [m²]	74
Total number of Unit C	8

FIG.115 1:100 Longitudinal section EE

FIG.116 Kitchen and dining area in unit C

UNIT A AND B

FACADES & LOCATION ON SITE

Unit A is the smallest dwelling with one bedroom and unit B is the medium sized dwelling with two bedrooms. Unit A and B has a similar facade as unit C, except the glazed panels on the thatched facades are not divided into two. This cluster of unit A and B are two one level dwellings which means there is a height difference between the previous mentioned cluster and this. This gives a dynamic to the urban area and courtyards, while walking on site.

FIG.117 1:200 South/East facade

FIG.118 1:200 South/West facade

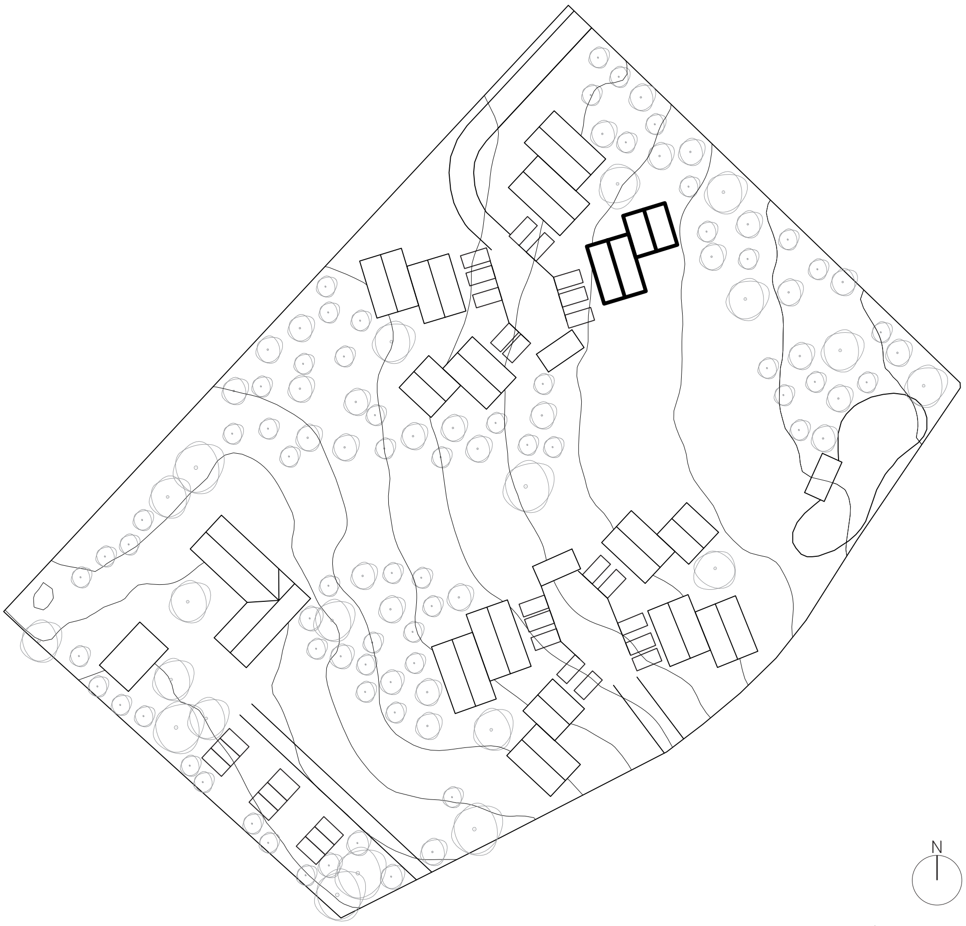


FIG.121 Location of the dwelling

FIG.119 1:200 North/West facade

FIG.120 1:200 North/East facade

FIG.122 1:100 Plan layout of unit A and B

Unit A has one bedroom where some of these dwellings also are designed for people with disabilities. Unit B is the most frequent dwelling in the co-housing, because there were more requests for this size of dwellings in Favrskov municipality (appendix 4). The section shows the low building height. This is done to avoid large indoor rooms and rather adapt to the human scale. The bedrooms, bathroom and kitchen have a flat ceiling in a height of 2,5m while the living room has a full ceiling height to the roof construction.

Unit type	A&B
Area Unit A [m²]	49
Area Unit B [m²]	68
Total number of Unit A	5
Total number of Unit B	11

FIG.123 1:100 Cross section FF

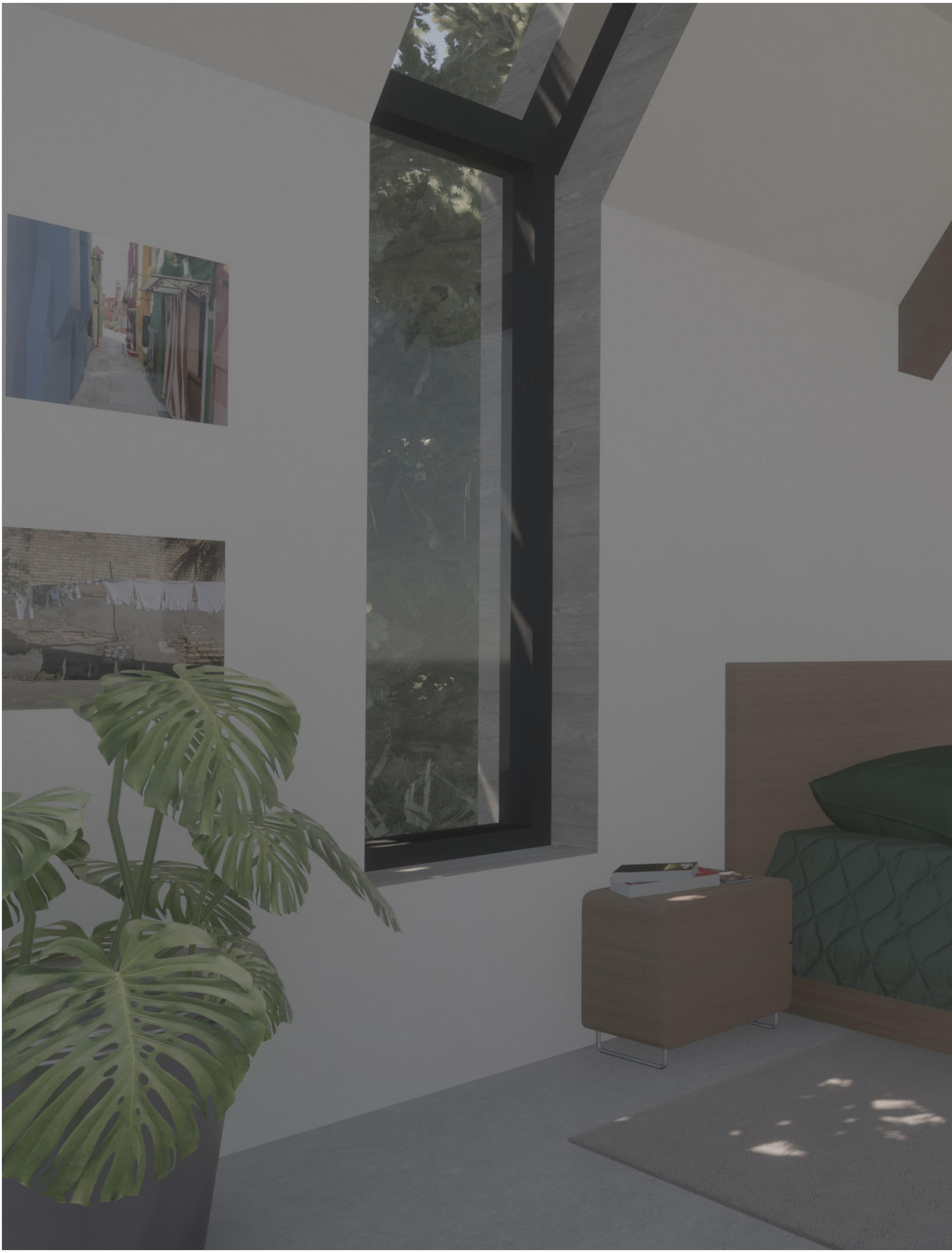


FIG.124 Bedroom in unit B

CONSTRUCTION

The construction in the new dwelling consists of a beech timber construction with stabilizing floors and gables. The construction is visible in the dwellings which is decided to give the atmosphere of a raw and honest building structure. The long inner walls in the dwellings separating the common area and the bedrooms, are made of unfired clay bricks and colored clay mortar as surface. This wall will also act as a stabilizing structure and furthermore, contribute to comfortable atmospheric comfort.

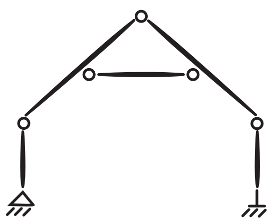


FIG.125 Static system of one floored dwellings

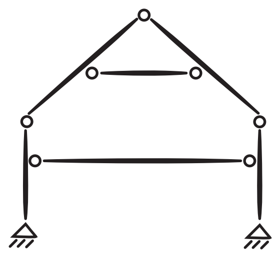


FIG.126 Static system of two floored dwellings

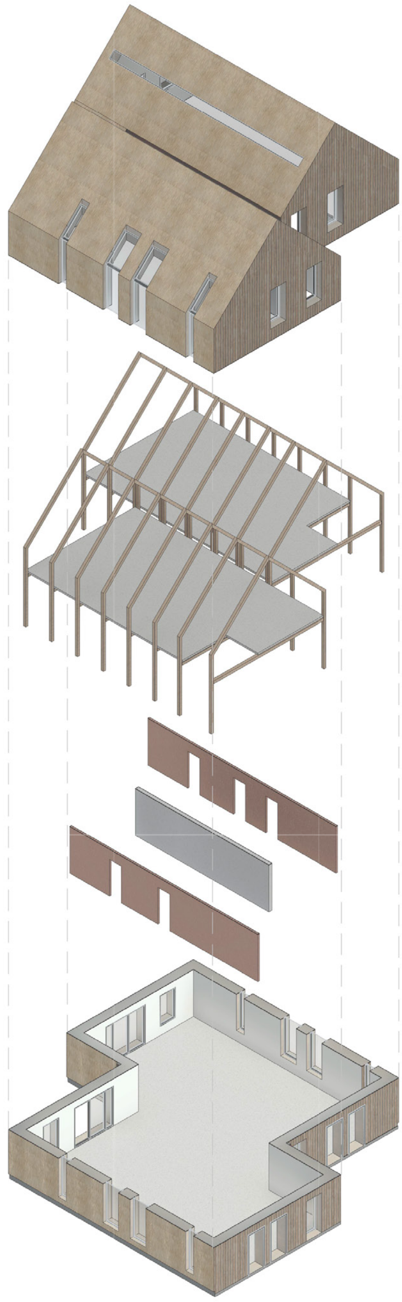


FIG.127 Exploded view of construction

VENTILATION

The mechanical ventilation in unit A and B lies above the bedrooms, bathroom, and kitchen where exhausts are placed in the kitchen and bathroom and fresh air is blown into the bedrooms. Single sided ventilation can be used in the bedrooms, bathroom, and kitchen during the summer season. Stack ventilation can be used in the living room where the skylight is located. Cross ventilation could be a possibility, if a door to a bedroom is open.

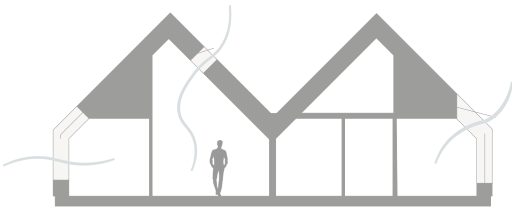


FIG.128 Natural ventilation princip

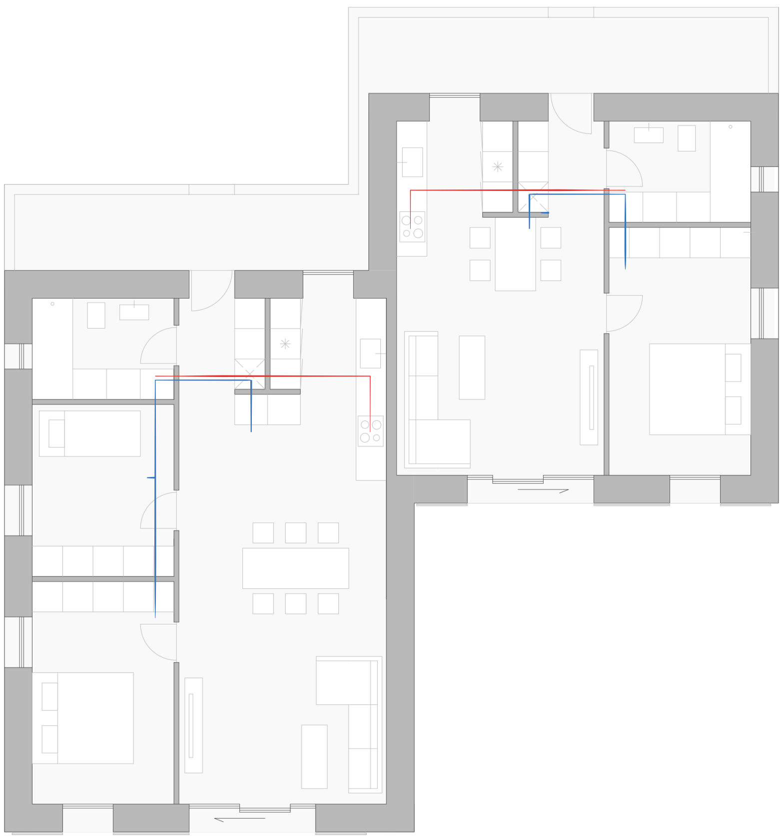


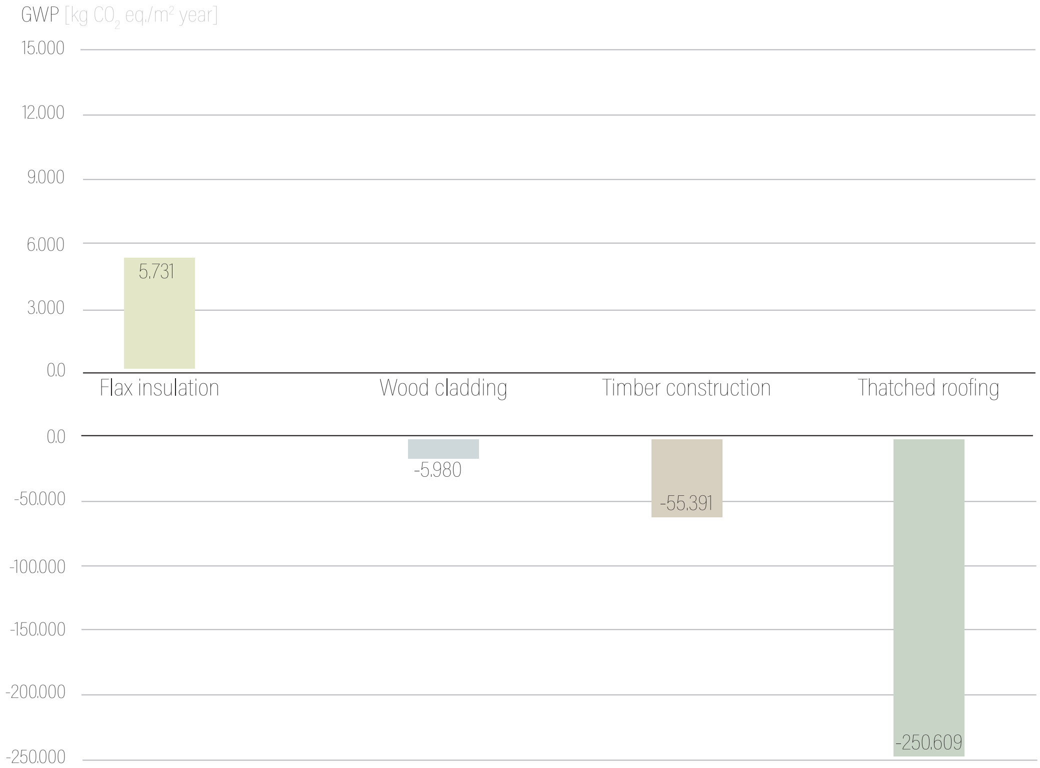
FIG.129 1:150 Mechanicel ventilation in unit A and B

LIFE CYCLE ASSESMENT ON UNIT B

The material with the largest CO2 emission from the dwellings is the flax insulation. This would have been higher if choosing another insulation material, since different insulation types were compared in the sketching phase of a unit C. The last three materials are negative most likely because of their embodied carbon within. The reason why the thatched roof was extended along the sides, was because of its low CO2 emission values.

RESULT NEW DWELLING, UNIT B

GWP	ODP	POCP	AP	EP	ADPe	ADPf	PEtot
[kg CO_2 eq.]	[kg R11-eq.]	[kg Ethene eq.]	[kg SO_2 eq.]	[kg Phosphate-eq.]	[kg Sb eq.]	[Mj]	[KWh]
-3,06E+05	1,59E-05	1,55E+03	-3,36E+03	1,69E+01	4,67E-01	3,64E+05	1,17E+06



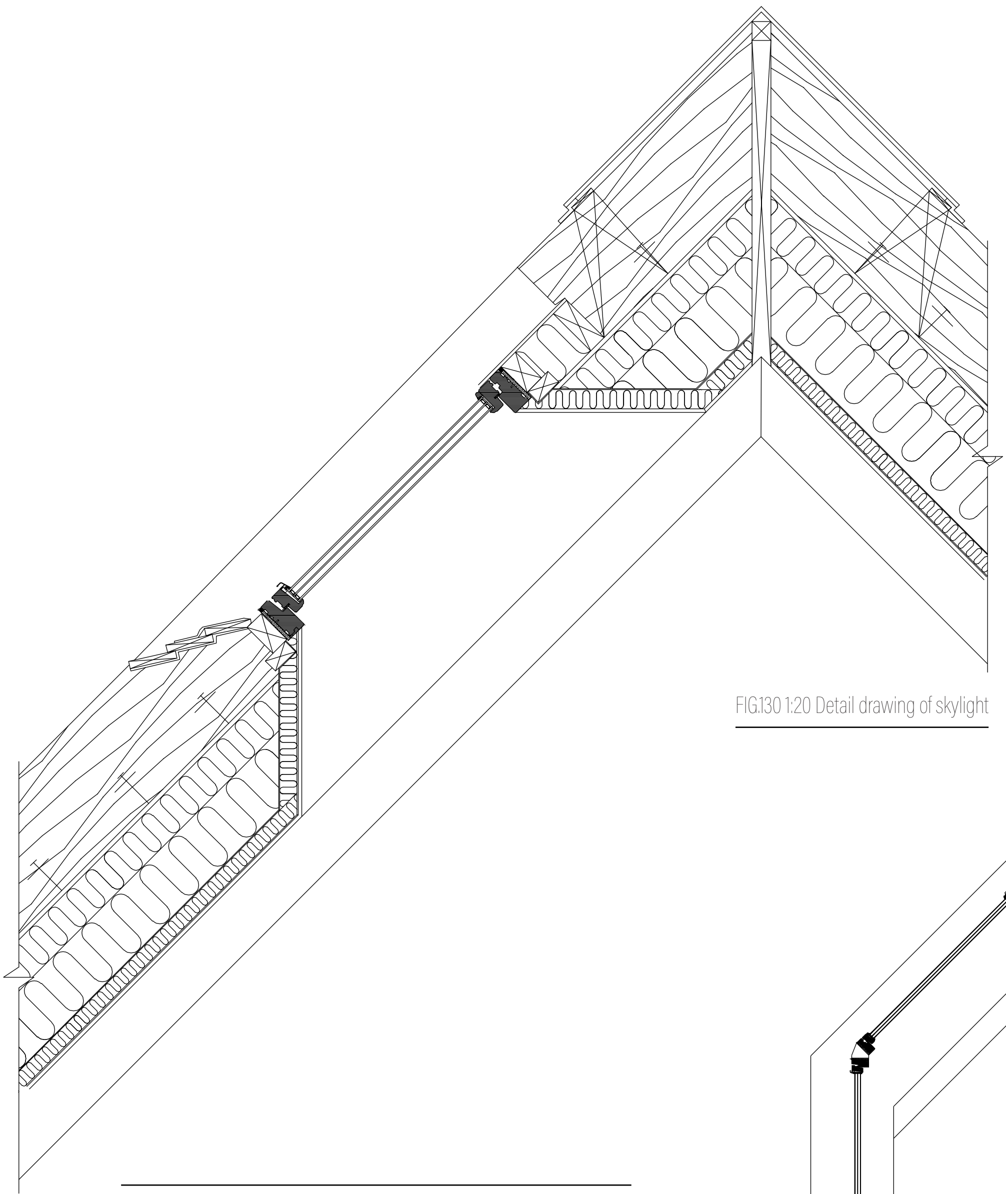


FIG.130 1:20 Detail drawing of skylight

DETAIL DRAWING

The dwelling is cladded with thatched roofing along the sides which has a big influence on the window placement. The window can not be plane with the exterior wall, since the straw needs a minimum thickness of 30cm. Therefore, the window has a depth of 30cm. Since the beginning of the project, there was a wish to have the window frame as a furniture in the dwellings but this is a difficult task when thatched facades also is a priority.

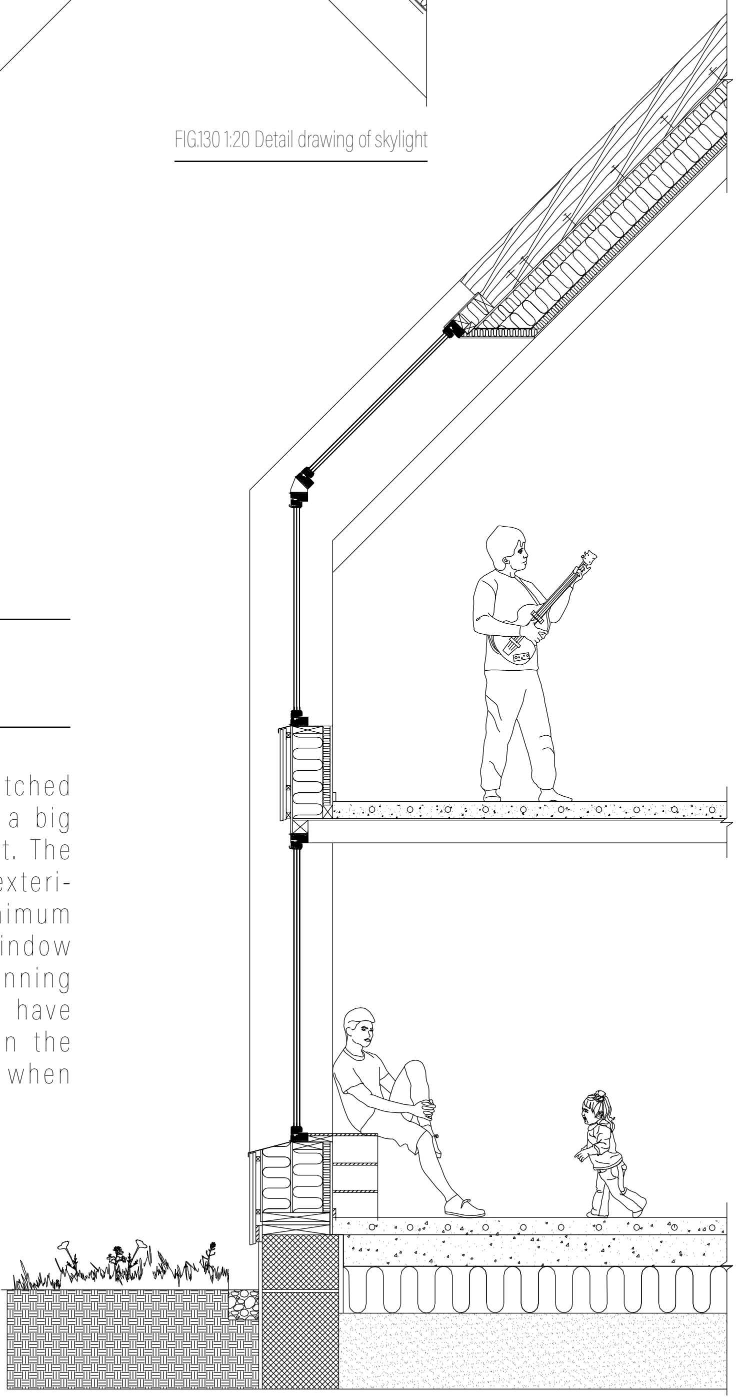


FIG.131 1:50 Detail drawing of two floored dwelling

DAYLIGHT ON UNIT C

The shown illustration is the daylight of unit C in two levels, since this was the most difficult dwelling to design for a comfortable daylight factor because of its long shape. The dwelling at the first floor has some trouble with the daylight in the middle of the common because there are no skylight. To have a larger percentage of daylight in the common area, a window could be implemented in the kitchen. This topic is further discussed in the reflection. The second floor receives a great amount of daylight because of the skylight which gives a very evenly spread of daylight in the common area.

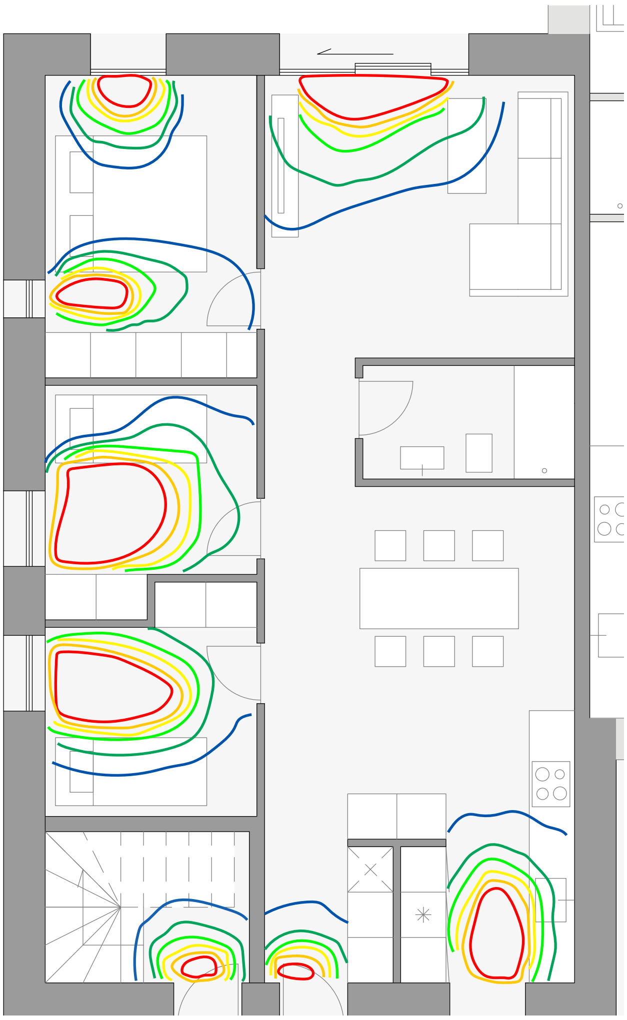


FIG.132 1:100 Daylight on 1. floor

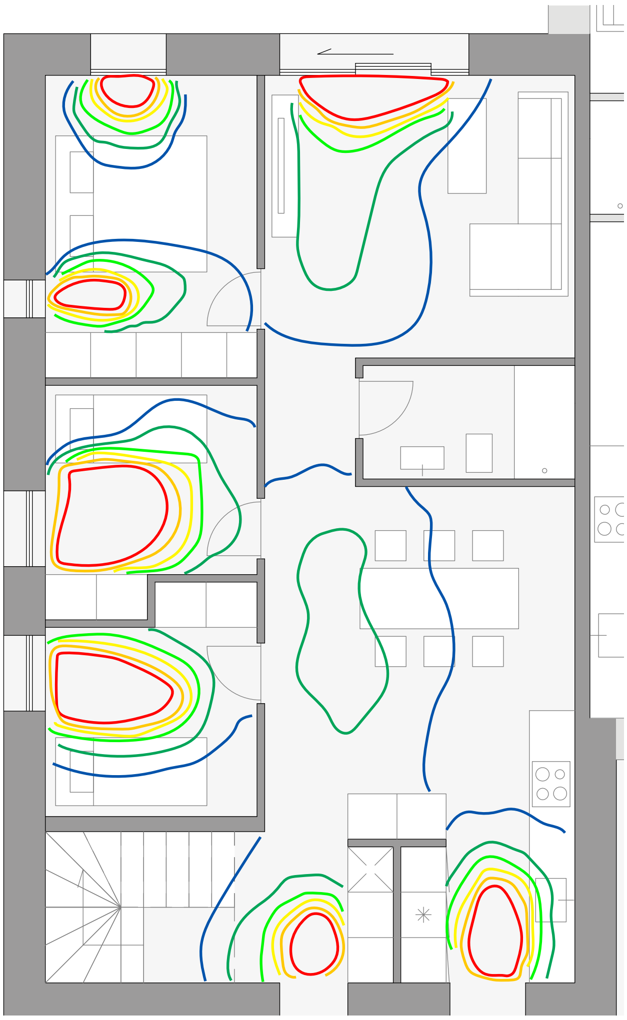


FIG.133 1:100 Daylight on 2. floor

BE18 ON UNIT A AND B

Through the design Be18 have been used to optimize the dwellings so they will fulfill the low energy frame. Early in the process the importance of the transmission loss in the building envelope were acknowledged. With focus on minimizing the transmission loss the dwellings became connected so they would share a wall. The most optimal way of minimizing the transmission loss would be to put all the dwellings side by side, but the vision for the cohousing were to give the residents a feeling of being close to nature. Placing the dwellings to close together would take away the farming experience and create instead create a village. Therefore, the end result is a combination of optimizing the dwelling and keeping the open landscape and views to nature. All the units were paired two together and some were in 2. floors. This created diversity in the building form and by having less ground area larger urban areas were possible.

Be18 were made based on a cluster of a Unit A and Unit B. For futher detail see appendix 13. This were the cluster with the most external surfaces compared to the floor area. With the use of active and passive strategies the energy frame was lowered to 29,5 kWh/m2 pr. year. It was not quite low enough, but without compromising the dwellings architectural and spatial qualities, there would be placed 1,5m2 solar cells pr unit. This made the dwellings achieve the low energy frame.

ENERGY REQUIREMENT [kWh/m² pr. year]	
Low energy frame	27
Total energy requirement	29,5
Total energy requirement with solar cells	26,3
CONTRIBUTION TO ENERGY REQUIREMENT [kWh/m² pr. year]	
Heat	0,0
El.for operation of the building	14,1
Overheating in the room	2,7
NET REQUIRMENT [kWh/m² pr. year]	
Room heating	23,8
Domestic hot water	16,2
Cooling	0,0

BSIM ON UNIT A

A good indoor environment is important when designing buildings for the user's wellbeing. To ensure thermal and atmospheric comfort the most critical building is simulated in BSim. In this project a unit A with an open landscape toward south were chosen. Unit A is the dwelling with the largest exterior area compared to the floor area. The living room are designed with large windows to enhance the view the building is facing that is towards south which create challenges with overheating. As shown in the process, different passive cooling strategies were tested. As end result the windows towards south were placed along the inner wall and vertical movable shading were placed on the facade. The movable shading ensures user control and are highly effective if the residents use them when needed. The downside is that the shading blocks the view, therefore the shading is created with small gaps so some of the views still are visible. As result there are 55h above 27º and 20h above 28º (Appendix 14). Fig. 134 shows how the natural ventilation helps keeping the temperature down during summer. Fig. 135 and 136 shows that the atmospheric comfort does not pass its limit on 650 ppm during summer and winter.

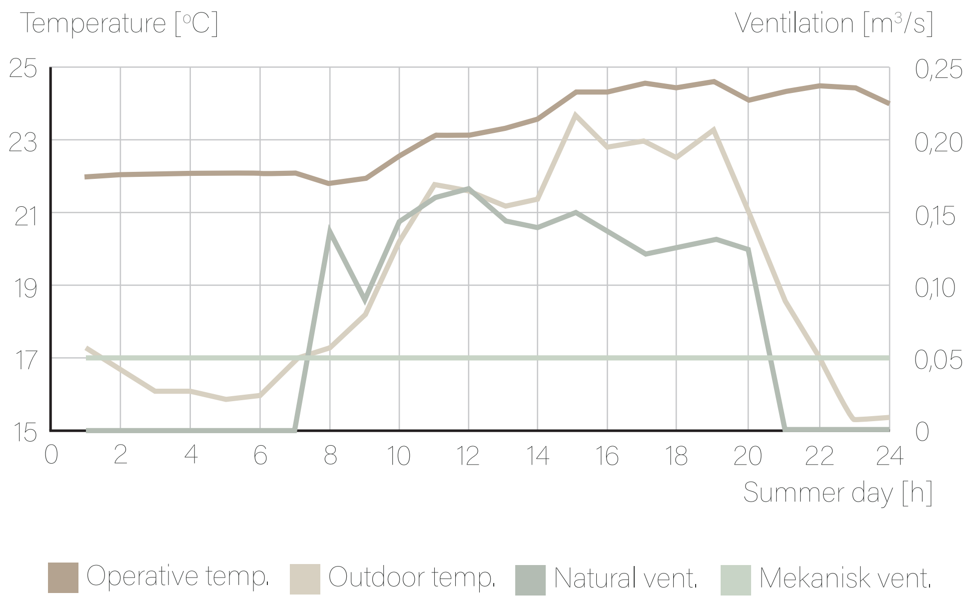


FIG.134 Operative temperature In a summer day

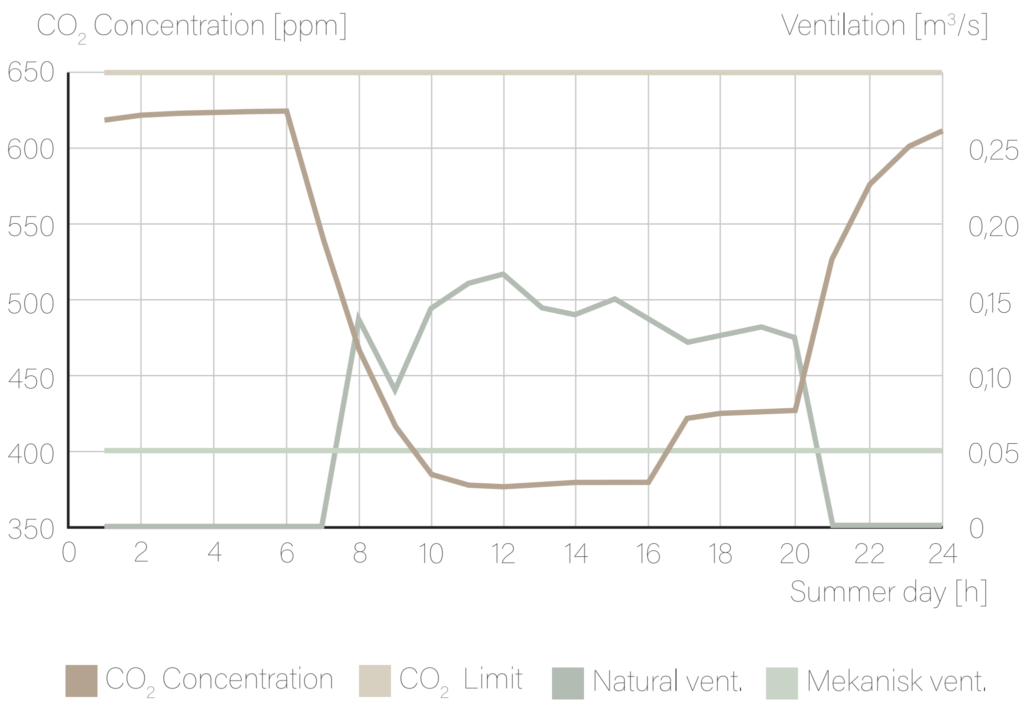


FIG.135 CO_2-concentration In a summer day

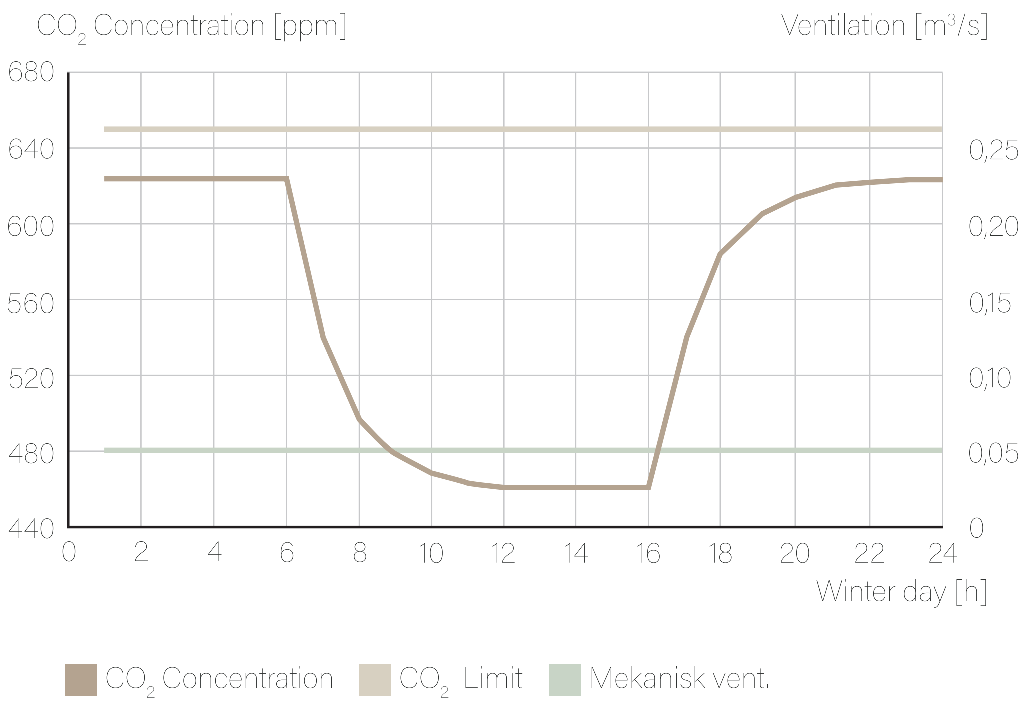


FIG.136 CO_2-concentration In a winter day

CHAPTER CONTENT

The chapter contain the sum up of the master thesis through a conclusion and reflection.

EPILOGUE

FIG.137 The arrival road to the farm house

CONCLUSION

From this project we can hereby conclude that it is possible to transform traditional farm buildings into alternative modern lifestyle dwellings and create a renewed view of the concept of living in the country. It is possible to renovate existing farm buildings and while still embracing the atmosphere by taking inspiration from the traditional building techniques. A renovation can be a process where the history of the given location is respected by preserving and integrating architectural elements from the original building period.

The societal view of the country lifestyle needs an update to give people alternative living conditions and by listening to the residents, there is clearly a wish for this. The social aspect of living in a co-housing can decrease the otherwise growing problem of loneliness and connect people across ages with similar interests and hobbies.

By transforming the increasing number of empty farmhouses and giving them new purpose it is possible to minimize demolition of capable materials that still can serve a purpose. Furthermore, it is possible to reuse materials and give them new life. Reused materials often tell a story that can contribute with a greater connection to a very specific location. The reuse of materials is an affordable step closer to decreasing the problem of global warming.

REFLECTION

The life cycle assessment has been difficult to value on the existing farm building because the program does not directly take account for renovation projects. For further investigation of the life cycle assessment it would have been interesting to have an overview of the existing farm life cycle and the renovated life cycle as a comparison. Also, to see the environmental save there is, by renovating instead of demolition

There was some trouble achieving enough daylight in unit C on the first floor. This problem was highlighted too late in the process which resulted in a less integrated compromise by having a window at the kitchen. Of course the shift between the building volume could be larger, and hereby have a longer facade to the outside, but this would create trouble concerning energy consumption.

The placement of the technical shaft in the dwellings could have been shared between the two buildings, but because of lack of attention to technical aspects, it was placed after the plan layout took its shape. Even though the technical shaft is not shared, the plan layout for the piping is well solved. The piping of the mechanical ventilation in the common dining area of the common house could also have been more thorough. There was a wish to preserve the valved ceiling in the stable, which made it difficult to hide the mechanical ventilation. The rustic look of the visible ventilation shaft might contribute to the rustic atmosphere of the stable, but it could also weaken the importance and visual effect of the valved ceiling.

Early on in the project there was an idea of utilizing the window frames as furniture in the dwellings. The thatched roofing made it impossible to align the window with the exterior facade, and thereby the idea crumbled. The group valued low CO2 emission and sustainable building materials above seating areas in the windows. If there were more time, the finish between the material choice and architectural spatial qualities would have been refined.

Overall it has been a great project with great guidance from our supervisor and it has been interesting to work with a subject that has large interest. The group dynamic has also been great but a lot more different than previous projects because of fewer group members. The group found out that the writing and research process was a lot more work, with only two group members. Contrary, the sketching phase was a lot easier because of the quick decision making and less discussions. The great aspect of a small group is the great influence in decision making and the final outcome which gives a feeling of ownership.

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ILLUSTRATIONS

FIG.01 Own illustration

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FIG.36-137 Own illustration